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ERRATA

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Page 304. The statement following the legend for Fig. 8, "External edge of sheath inadvertently omitted," applies to Fig. 6 rather than Fig. 8.

Page 400, line 17: for "Trinemam" read "Trinema."

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CHEMISTRY.—*The ammoniation of waste sulfite liquor and its possible utilization as a fertilizer material.*[1] Max Phillips, M. J. Goss, B. E. Brown, and F. R. Reid, Bureau of Chemistry and Soils.

The preparation of paper pulp by the sulfite process consists essentially in heating wood, under pressure, with an aqueous solution of calcium bisulfite and sulfurous acid. This operation converts the lignin into so-called lignin sulfonic acids, which are soluble in water, and leaves the cellulose in a more or less pure state. The spent liquors containing the lignin sulfonic acids, commonly referred to as "waste sulfite liquor," are generally discarded, and the disposal of this material aggravates seriously the river pollution problem. It is estimated that in this country alone approximately 1,500,000 tons of lignin are annually discharged from the various pulp-wood mills.

Although the problem of utilization of waste sulfite liquor is one upon which considerable research work has been done by many chemists, in this country and abroad, it is still largely unsolved. Attempts have been made to utilize this liquor in connection with the preparation of binding materials, adhesives, sizing and tanning materials, dyes, and as a fertilizer, but without much success. A review of the literature on the utilization of waste sulfite liquor is given in a bulletin by Johnsen and Hovey (1). Of the more recent publications on the utilization of waste sulfite liquor as a fertilizer may be mentioned that of Bokorny (2), and that of Görbing (3). Bokorny applied to the soil some waste sulfite liquor from which the sugars had been removed by fermentation with yeast, and obtained increased yields of wheat, peas, and potatoes. Görbing, however, failed to confirm the findings of Bokorny.

[1] Contribution no. 230 from the Color and Farm Waste and the Soil Fertility Divisions, Bureau of Chemistry and Soils. Received October 16, 1933.

In this paper a preliminary report is made on some experiments on the ammoniation of waste sulfite liquor. In view of the relatively large amounts of organic matter, chiefly lignin, present in waste sulfite liquor, and in view of the known chemical properties of lignin, it seemed worth while to attempt to ammoniate this material in the hope of thus obtaining a nitrogenous product having the nitrogen chemically bound to the organic material. The results thus far obtained indicate that it is possible to obtain a product containing as much as 10 per cent nitrogen, of which only a negligible amount is present in the form of ammonium salts.

For the ammoniation experiments a batch of fresh waste sulfite liquor was obtained from a paper pulp mill.[2] A portion of this was evaporated to dryness, dried at 105° C., and analyzed by the standard A. O. A. C. methods (4). The following results were obtained:

Total P_2O_5—None
Total N—0.04 per cent
Total K_2O—0.15 per cent

A second portion of the waste sulfite liquor was neutralized with ammonia, evaporated to dryness, and dried at 105°C. (A). The total nitrogen content of this amounted to 2.60 per cent. In all the subsequent ammoniation experiments, this material (A) was used. The ammoniation was carried out in two steel bombs which revolved in an oil bath provided with thermostatic control. A full description of the apparatus has been given elsewhere (5). Into each bomb 50 g. of the dry material and 300 g. aqueous ammonia (28 per cent NH_3) were placed. In each experiment, the reaction products from the two bombs were combined, evaporated to dryness on the steam bath, and dried at 105°C. Two series of experiments were conducted, one at 200°C. and the other at 220°C., in which the time of heating was varied. The dried products obtained varied in color from dark brown to black. The analyses of these products are recorded in Tables 1 and 2. (The total nitrogen and ammoniacal nitrogen were determined by the standard A. O. A. C. methods [*loc. cit.*].)

A more detailed report of the ammoniation process, together with additional data, will be published later. Attention is, however, called to the relatively high nitrogen content of the preparations and to the low, almost negligible percentages of ammoniacal nitrogen.

[2] The sulfite liquor used in our experiments was kindly supplied by the Brown Company of Berlin, New Hampshire.

TABLE 1.—AMMONIATION OF DRY RESIDUE OF SULFITE LIQUOR AT 200°C.

100 g. of the dry residue of neutralized sulfite liquor (A) and 600 cc. Aq. NH_3 were used for each experiment.

Experiment No.	Time of Heating (Hours)	Total N in Dry Product (per cent)	Ammoniacal N in Dry Product (per cent)
1	4	7.30	1.23
2	8	8.32	0.36
3	12	8.83	0.20
4	16	8.56	0.22
5	20	9.07	0.19

TABLE 2.—AMMONIATION OF DRY RESIDUE OF SULFITE LIQUOR AT 220°C.

100 g. of the dry residue of neutralized sulfite liquor (A) and 600 cc. Aq. NH_3 were used for each experiment.

Experiment No.	Time of Heating (Hours)	Total N in Dry Product (per cent)	Ammoniacal N in Dry Product (per cent)
1	4	8.82	0.33
2	8	9.56	0.20
3	12	9.95	0.13
4	16	9.92	0.15
5	20	10.55	0.09

FERTILIZER VALUE OF AMMONIATED MATERIAL

After ammoniation of the waste sulfite liquor is effected the chief problem is how to utilize the product to most economical advantage. A natural query is, "Does it possess any value as a fertilizer material?" On the basis of nitrogen content, running as high as 10.5 per cent, the ammoniated sulfite lignin rates with fish scrap, tankage and cottonseed meal, which have been found to be valuable fertilizer materials. Just how available the nitrogen in the ammoniated product is to plants as compared with some of the regular nitrogenous fertilizer materials can best be determined by vegetative tests under greenhouse or field conditions. Accordingly, preliminary tests were made in the Soil Fertility Greenhouse at Arlington Farm to determine this point. In making the greenhouse tests, 1-gallon glazed pots were used. The soil used, designated Norfolk loamy fine sand, was obtained in nearby Virginia and possessed a pH of 4.8. Both limed and unlimed soil tests were made. Millet was used as the test crop.

In making the preliminary vegetative tests 5 samples of the dry residue of ammoniated waste sulfite liquor ranging in nitrogen content from 2.6 to 9.07 per cent were mixed with commercial super-

phosphate and muriate of potash on a 4–12–4 basis.[3] These 5 mixtures were compared with (1) a mixture containing only superphosphate and muriate of potash, an 0–12–4 mixture; (2) a 4–12–4 mixture with dried blood as the source of nitrogen; and (3) a 4–12–4 mixture with nitrogen derived equally from sodium nitrate and ammonium sulphate.

Additional tests included liming the soil to reduce the soil acidity to a pH of 6.8 from an original of 4.8 and replanting one of the series without further fertilizer treatment to determine how much, if any, residual effect may be expected from the ammoniated material.

The results of these preliminary tests show that while a much better growth of millet was obtained with the ammoniated material as a source of nitrogen in the 4–12–4 mixture than with the 0–12–4 mixture, in no case was the response equal to that obtained with either dried blood or the mixture of sodium nitrate and ammonium sulphate. Expressing the results of the pot tests relatively, with the 0–12–4 at 100, the ammoniated material is 128.7; dried blood, 187.2; and the inorganic salts, 193.6.[4] The oven dried weights in grams, average of 5 sets, were as follows: 0–12–4 mixture, 22.13 grams; 4–12–4 (ammoniated sulphite lignin as source of N), 28.48; dried blood mixture, 41.42; and inorganic salts mixture, 42.84.

Liming the soil provided better growing conditions for the millet test crop, but whether increased growth was due to change of pH or to an increase in the availability of the ammoniated material, or perhaps to both of these factors, was not determined in these tests. To do so would have required the inclusion of an 0–12–4 treatment on limed soil. However, the growth of millet on the limed soil failed to equal that produced with either dried blood or the inorganic salts on unlimed soil.

One of the pot tests of the ammoniated material (8.32 per cent N) was replanted to millet without further fertilizer treatment, with results expressed relatively as follows: 0–12–4 mixture, 100; 4–12–4 mixture, ammoniated material as a source of nitrogen, 77.7; dried blood mixture, 60; and inorganic salts mixture 44, thus indicating the possibility that the nitrogen in the ammoniated material is made available over a longer growing period than that in either the dried blood or the inorganic salts. The oven dried weights of the millet

[3] Four per cent nitrogen (N); 12 per cent phosphoric acid (P_2O_5); 4 per cent potash (K_2O). Rate of fertilizer application, 2000 pounds to the acre.

[4] These figures represent the relative weights of oven dried plant material obtained from an average of 5 tests.

plants in the replanted series were as follows: 0–12–4 mixture, 12.15 grams; ammoniated mixture, 9.45; dried blood mixture, 7.30; and inorganic salts mixture, 5.35 grams.

The relatively better showing of the 0–12–4 mixture in the replanted series was probably due to the greater residues of phosphoric acid and potash; the soil used being particularly responsive to the former fertilizer element. The influence of the mixtures containing nitrogen, on account of heavier growth, was no doubt to remove more phosphoric acid and potash than did the plants grown without added nitrogen materials. When replanted without additional treatment the presumably greater residues of phosphoric acid and potash in the 0–12–4 pots probably induced a greater growth than occurred in the pots to which the nitrogen materials also were added. This statement may apply equally to the result obtained in the replanted series with ammoniated waste sulfite liquor, which produced a better yield of millet than either the dried blood or inorganic salts mixture.

In experimental work now in progress, the effect of varying residues of phosphoric acid and potash is practically being taken care of by replenishing these plant food constituents, thus making the response largely one dependent upon the residual nitrogen supply.

Before final evaluation of the ammoniated material as a fertilizer, it will be necessary to conduct other tests by employing different soils and crop plants and by using the ammoniated sulfite liquor as a partial rather than as an entire source of nitrogen. It will also be essential to determine its value as a conditioning material in mixed fertilizers and as a soil mulch, and its relative effectiveness under field conditions on prominent soil types. Finally, it is interesting to note that notwithstanding the chemical nature of the original material before ammoniation, the resulting product showed up fairly well as a fertilizer material in comparison with standard nitrogen carriers.

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2. Bokorny, T. *Weitere Düngungsversuche mit entzuckerter Sulfitablauge.* Mitt. deut. Landw. Ges. **34:** 6. 1919. Ibid. **35:** 202. 1920.
3. Görbing, J. *Ueber die Verwertung von Zellstoffablaugen zu Düngezwecken.* Papier Fabrikant **25:** 573, 633, 671. 1927.
4. Official and tentative methods of analysis of the Association of Official Agricultural Chemists, 1930: 14–27. Association of Official Agricultural Chemists, Washington, D. C.
5. Phillips, M. *The preparation of 2-aminoanthraquinone from phthalic anhydride and chlorobenzene.* Ind. Eng. Chem. **17:** 721. 1925.

HYDROLOGY.—*The history and development of ground-water hydrology.*[1] OSCAR EDWARD MEINZER, U. S. Geological Survey.

UTILIZATION OF GROUND WATER

Digging for water is doubtless a very ancient art. Indeed, even some of the lower animals, such as the coyote, are known to dig down to water where it occurs not far below the surface. However, in the early stage of human development, men progressed very little beyond the coyote in well digging because they lived near springs or streams which were convenient for fishing and hunting.

When men began to raise large herds and flocks, the grazing within reach of natural watering places became inadequate; and the task of digging wells was taken up seriously, especially in arid and semi-arid regions. Thus, the patriarch Isaac was very active and successful in digging wells, as is shown by the twenty-sixth chapter of Genesis, which reads like a water-supply paper.

When men began to cultivate the soil the need for water supplies was further increased. Some of the most ancient agriculture was carried on in arid regions by means of irrigation, largely with water drawn from wells. Throughout the countries of southern Asia and northern Africa, ground water has, since ancient times, been extensively utilized for irrigation. It has been estimated that on the peninsula of India alone not less than 20,000,000 acres are under irrigation with water obtained from wells—an acreage comparable with the total irrigated area in the United States.[2]

With the growth of cities and the development of industry, the demands for new water supplies increased immensely, and these supplies were in large part obtained from wells. At present about two-thirds of the public waterworks in the United States derive their water from wells and these waterworks supply nearly 20,000,000 of our population. The ground-water developments for industrial purposes have become numerous and complex, and the requirements have become very exacting as to both quantity and quality of water.

The utilization of the ground water, of course, preceded by long

[1] Presidential address delivered before the Geological Society of Washington, Dec. 9, 1931. The term *ground water* is here used to designate the water in the zone of saturation; that is, the water which supplies springs and wells. The terms *underground water*, *subterranean water*, and *phreatic water* are also used to designate this water. The term *phreatic* is derived from the Greek word meaning *a well*. It suggests the term *phreatology* for the branch of science that is here designated by the awkward term *ground-water hydrology*. Published with the permission of the Director, U. S. Geological Survey. Received March 23, 1933.

[2] Cox, W. G. *Artesian wells as a means of water supply*. Brisbane, pp. 3–7. 1895.

ages the scientific study of the natural laws that govern the occurrence and movement of this water. However, the problems of utilization have furnished the chief urge for scientific study, and most of the men who have made contributions to ground-water hydrology have been close to the practical problems of ground-water development.

ORIGIN OF GROUND WATER[3]

From the dawn of history nearly to the present, the source of the water that flows from the springs has constituted a puzzling problem that has been the subject of much speculation and controversy. Prior to the latter part of the 17th century it was generally assumed that the water discharged by the springs could not be derived from the rain, first because the rainfall was believed to be inadequate in quantity, and secondly, because the earth was believed to be too impervious to permit penetration of the rain water far below the surface. With these two erroneous postulates lightly assumed, the philosophers devoted their thought to devising ingenuous hypotheses to account in some other way for the spring and stream water. Two main hypotheses were developed: one to the effect that sea water is conducted through subterranean channels below the mountains and is then purified and raised to the springs; the other to the effect that in the cold dark caverns under the mountains the subterranean atmosphere and perhaps the earth itself are condensed into the moisture which feeds the springs.

The sea-water hypothesis gave rise to subsidiary hypotheses to explain how the sea water is freed from its salt and how it is elevated to the altitude of the springs. The removal of the salt was ascribed to processes of either distillation or filtration. The elevation of the water was by different writers ascribed to processes of vaporization and

[3] The following publications give interesting and valuable accounts of the historical development of the theories on the origin of ground water:

ADAMS, F. D. *The origin of springs and rivers—an historical review.* Fennia **50**: No. 1, Helsingfors, Finland, 1928. See also abstract in Geol. Soc. Amer. Bull. **39**: 149–150. 1928; and note on *Rainfall and Runoff* in Science. **67**: 500–501. 1928.

ALTHAUS, JULIUS. *The spas of Europe.* London, pp. 1–9. 1862.

HAAS, HIPPOLYT. *Quellenkunde.* Leipzig, 1–10. 1895.

IMBEAUX, ED. *Essai d'hydro-géologie.* Paris, pp. 16–18. 1930.

KEILHACK, KONRAD. *Lehrbuch der Grundwasser und Quellenkunde.* Berlin, pp. 74–85. 1912.

MAGER, HENRI. *Les Moyens de découvrir les eaux souterraines et de les utiliser.* Paris, pp. 1–21. 1912.

MARTEL, E. A. *Nouveau traité des eaux souterraines.* Paris, pp. 77–98. 1921.

PARAMELLE, L'ABBÉ. *L'Art de découvrir les sources.* 1856. Fourth ed. 1896, pp. 64–112.

subsequent condensation, to rock pressure, to suction of the wind, to pressure exerted on the sea by the wind and waves, or later to capillary action. One curious explanation was that, owing to the curvature of the earth, the water in the middle of the ocean is actually at a much higher altitude than the springs and hence furnishes the necessary head.

The Greek philosophers.—We can well be sympathetic with the misconceptions of the old Greek philosophers, who were pioneering in the vast untrodden fields of thought. It appears to me that in some respects they were not very far from the truth. The Greeks were familiar with cavernous limestone terranes, and hence they conceived the subterranean regions to have great open spaces with natural processes comparable with those on the surface. The writings of Homer (about 1000 B.C.), Thales (about 650 B.C.), and Plato (427–347 B.C.) contain passages which indicate that these ancient philosophers correctly believed that the spring water is derived from the ocean, but erroneously postulated that this return flow occurs through subterranean channels. Aristotle (384–322 B.C.) on the other hand, developed the hypothesis of subterranean condensation which was suggested by the condensation of atmospheric water vapor. Quoting from Adams[4]:

> Aristotle said that the air surrounding the earth is turned into water by the cold of the heavens and falls as rain. He goes on to say that it is unreasonable for any one to refuse to admit that the air which penetrates and passes into the crust of the earth also becomes transformed into water owing to the cold which it encounters there. Within the earth's crust it is condensed in the form of moisture which gathers into drops that run together into little trickling streams, so that the sources of the rivers as it were drip out of the earth and unite on its surface into brooks and rivers. The rivers thus flow from the mountains, because the mountains and high lands are suspended over the lower country like a saturated sponge. It is on the mountains also the chief rainfall occurs and the water coming out of the earth unites with the rain water to produce rivers. The rainfall alone is, he states, quite insufficient to supply the rivers of the world with water. The ocean into which the rivers run does not overflow because while some of the water is evaporated, the rest of it changes back into air or into one of the other elements.

The Roman philosophers and Vitruvius.—The Roman philosophers in general followed the Greek ideas, and did not contribute much to the Greek hypotheses except erroneous details. Seneca (3 B.C.–65 A.D. ?) accepted Aristotle's condensation hypothesis, while Pliny (23–79 A.D.) adopted the sea-water concept and attempted to explain how the water is elevated.

[4] *Op. cit.*, p. 4. From Meteorologia, Book I, 13.

The theory now generally accepted that the ground water is for the most part derived from rain and snow by infiltration from the surface, was briefly but clearly stated by Marcus Vitruvius, who lived about the time of Christ. Vitruvius was not a philosopher but an architect. He produced a work on architecture in ten books, and in conformity with the importance given by the Romans to water supplies, he devoted one of the 10 books to that subject. At the beginning of Book 8, as quoted from the English translation by Givilt,[5] he stated:

> As it is the opinion of physiologists, philosophers, and priests that all things proceed from water, I thought it necessary, as in the preceding seven books rules are laid down for buildings, to describe in this the method of finding water, its different properties according to the varied nature of places, how it ought to be conducted, and in what manner it should be judged of; inasmuch as it is of infinite importance for the purposes of life, for pleasure, and for our daily use.

The mountains, he explained, receive a large amount of rain, which they allow to percolate through the rock strata to their base, where, issuing forth, it gives rise to streams.

The writers of the Dark Ages.—During the Middle Ages, according to Adams,[6] all the philosophers and interpreters of Holy Scripture, from St. Jerome (340–420 A.D.) down, taught that the springs have their origin in the ocean. They generally based this assumption on passages in the Bible such as Ecclesiastes **1**, 7: "All the rivers run into the sea, yet the sea is not full; unto the place from whence the rivers come thither they return again." These writers stated that the sea water escapes through holes in the bottom of the ocean, flows into the bowels of the earth, and thence is elevated to the springs.

The early period of modern times—Bernard Palissy.—Beginning with the middle of the 16th century numerous publications appeared which contained discussions of ground water, some of them relating primarily to this subject. Until near the close of the 17th century the two old Greek hypotheses chiefly occupied the field, with many fantastic adornments, although the infiltration theory was explained by a few writers, especially in 1580 by Bernard Palissy[7] (1509–1589), French Huguenot, inventor of enameled pottery, and pioneer paleontologist.

Palissy was reared in poverty and was not educated in Greek or Latin. He began early to observe nature and he based his theories on

[5] Givilt, Joseph. *Architecture*, by Marcus Vitruvius Pollio, Book **8**: 177–200. Translated from the Latin, 1860.

[6] *Op. cit.*, pp. 8, 9.

[7] Palissy, Bernard. *Discours admirable de la nature des eaux et fontaines tant naturelles qu'artificielles.* 1580.

his own observations. "I have had no other books," he wrote, "than Heaven and Earth, which are open to all." His discourse on water and springs was written in French, whereas the philosophic treatises of that period were generally in Latin. This discourse is in the form of a fascinating dialogue between "Theory" and "Practice."

"When for a long time," says Practice, "I had closely considered the cause of the sources of natural fountains and the place whence they might proceed, at length I became plainly assured that they could proceed from or be engendered by nothing but the rains." Theory replies: "After having heard your opinion I am compelled to say that you are a great fool. Do you think me so ignorant that I should put more faith in what you say, than in so large a number of philosophers who tell us that all waters come from the sea and return thither? There are none, even to the old men, who do not hold this theory, and from all time we have believed it. It is a great presumption in you to wish to make us believe a doctrine altogether new, as if you were the cleverest philosopher." To which Practice replies: "If I were not well assured in my opinion, you would put me to great shame; but I am not alarmed at your abuse or your fine language; for I am quite certain that I shall win against you and against all those who are of your opinion, though they be Aristotle and the best philosophers that ever lived; for I am quite assured that my opinion is trustworthy."

Thus the argument is developed. Theory defends first the sea-water and then the condensation hypothesis, while Practice, with clear and valid arguments, shows the absurdities of these hypotheses, and then presents simple but convincing evidence that the ground water is derived from rain.

Palissy's very sympathetic biographer, Henry Morley,[8] wrote in 1853 as follows of the reception that was given to Palissy's theory of ground water:

"By his immediate hearers Palissy's doctrine was accepted; and a few men, who read his books before they passed from obscure fame into unmerited oblivion, made practical use of his suggestion. But by the body of his countrymen, in his own day, the character of Palissy as a philosopher was not appreciated. He was one or two—now and then even three—centuries in advance of his own time, so that his own time had not ears to hear him with. Moreover, France was busy upon other matters, and had no leisure to think for half a minute about springs of water while there prevailed a more engrossing interest in pools of blood."

Two great men of the 17th century who rejected or ignored the teachings of Palissy were the German astronomer Johann Kepler (1571–1630) and the French philosopher René Descartes (1596–1650). The hypothesis that the earth functions somewhat like an animal, or indeed that it is a living being, became current early in the

[8] Morley, Henry. *The Life of Bernard Palissy of Saintes.* 2 vols., Boston, 1853. The quotation and translation of dialogue are in **2**: 124. 125.

17th century and had adherents as late as the 19th century. Kepler adopted this hypothesis and expressed the opinion that the earth, like a huge animal, takes in the water of the ocean, digests and assimilates it, and discharges the products of these physiological processes through springs. Descartes taught that the sea water finds its way into the depths of the earth through underground channels and is there vaporized by the heat of the earth's interior; furthermore that the vapor rises through caverns, is condensed at higher levels, and thus supplies the springs.[9]

The age of Perrault, Mariotté, and Halley.—A new epoch in the history of hydrology began in the latter part of the 17th century through the work of Pierre Perrault (1608–1680) and Edmé Mariotté (1620–1684) and other French physicists, and of the English astronomer Edmund Halley (1656–1742). These men put hydrology for the first time on a quantitative basis. Perrault made measurements of the rainfall during three years; and he roughly estimated the area of the drainage basin of the Seine River above a point in Burgundy and of the run-off from this same basin. Thus he computed that the quantity of water that fell on the basin as rain or snow was about six times the quantity discharged by the river. Crude as was his work, he nevertheless demonstrated the fallacy of the age-old assumption of the inadequacy of the rainfall to account for the discharge of springs and streams. Mariotté computed the discharge of the Seine at Paris by measuring its width, depth, and velocity at approximately its mean stage, making the velocity measurements by the float method. He essentially verified Perrault's results. About the same time Halley made crude tests of evaporation, and demonstrated that the evaporation from the sea is sufficient to account for all the water supplied to the springs and streams, thus removing the need for Plato's Tartaros or any other mysterious subterranean channel to conduct the water from the ocean to the springs.

The relative credit that should be given to Perrault and Mariotté has been a question of considerable disagreement. A number of writers have stated that Perrault opposed the infiltration theory. Fortunately we have in the U. S. Geological Survey library a copy of the 1678 edition of his treatise on the origin of springs,[10] first published in 1674. If I read this text correctly Perrault did not argue against the

[9] See Keilhack, *op. cit.*, pp. 76, 77; Martel, *op. cit.*, p. 78; Paramelle, *op. cit.*, pp. 69, 70.

[10] *De L'origine des fontaines*, Paris, 1678. The name of the author does not appear in this volume but it is evidently Perrault's treatise. See also the previously cited note by Adams in Science, **67**: 500–501. 1928.

infiltration theory, but rather explained that, whereas Vitruvius and Palissy believed that ground-water recharge occurs chiefly from rain and snow on the mountains, he himself held that the rain feeds the streams directly, and that the seepage from the streams on the lower slopes supplies the ground water, which eventually returns to the surface in the lowlands.

Mariotté, who discovered Mariotté's law of gases, also known as Boyle's law, probably deserves more than any other man the distinction of being regarded as the founder of ground-water hydrology, perhaps I should say of the entire science of hydrology. In his publications, which appeared after his death in 1684, he defended vigorously the infiltration theory and created much of the modern thought on the subject.[11] According to the brief digest of his works by Keilhack,[12] he maintained that the water derived from rain and snow penetrates into the pores of the earth and accumulates in wells; that this water percolates downward till it reaches impermeable rock and thence percolates laterally; and that it is sufficient in quantity to supply the springs. He demonstrated that the rain water penetrates into the earth, and used for this purpose the cellar of the Paris Observatory, the percolation through the cover of which compared with the amount of rainfall. He also showed that the flow of springs increases in rainy weather and diminishes in times of drought, and explained that the more constant springs are supplied from larger underground reservoirs.

The ground-water literature near the close of the 17th century, throughout the 18th century, and in the early part of the 19th century, was largely devoted to the defense of the old hypotheses as against the infiltration theory. Nevertheless, the infiltration theory gradually but irresistibly gained ground and eventually became almost universally accepted among scientists, while the old hypotheses became more and more shadowy until they lurked only in obscure haunts like emaciated ghosts.

Modern defenders of the condensation hypothesis.—A rather comical revival of the condensation hypothesis of Aristotle was presented in 1877 by the German geologist Volger[13] before a meeting of the Society

[11] MARIOTTÉ, EDMÉ. *Traites du mouvement des eaux et des autres corps fluides,* 1686. According to Keilhack, the complete works of Mariotté were published in Leyden in 1717.

[12] KEILHACK, *op. cit.*, pp. 80, 81.

[13] VOLGER, OTTO. *Die wissenschaftliche Lösung der Wasser—insbesondere der quellenfrage, mit Rücksicht auf die Versorgung der Städte.* Ver. Deutscher Ing. Zeitschr., Berlin. **21:** 482–502. 1877.

of German Engineers, in which he took the extreme attitude that no ground water is derived from rain. Some of his statements were approximately as follows:

> No ground water is derived from rain water. No scientific doctrine is more unfounded and more fallacious than the doctrine in regard to the origin of spring water from rain water. . . . Even the strongest rain wets the earth only superficially, penetrates only a little into the uppermost crust and remains suspended therein. . . . After eight days of the most severe rainy weather the ground at the depth of one-half meter will not show the slightest trace of penetration by water. . . . If the ground were permeable to water, in the manner indicated by the prevalent doctrine in regard to springs, could we see before our eyes a river flow from the heights of the mountains to the sea? Even if the river were ever so richly supplied with water, would it not in its course have to lose its water if the water percolated into the ground? Would not every sea have to sink beneath the surface? Would not the same have to happen to the ocean in spite of its great volume of water? . . . The sea of air extends into the earth to unknown depths, perhaps to the center. The atmosphere, that is, the globe of the gaseous constituent of the aggregate earth, consists therefore not alone of the sea of air that lies above the land and water surfaces. The latter is rather only a slight appendage of the real atmosphere, the vapor-globe, which exists in the ground and in the whole earth. . . . One can say, in general, that all the rocks which constitute the earth, as far as we know them, take up a larger volume of air than their own bulk, so that the ground on which we stand thereby contains so much air that it is just as though the ground were entirely absent and the whole space which it occupies were filled with air.

This paper contained so many exaggerated and erroneous statements that it is surprising that it should have received much attention. On the contrary, however, it gave rise to numerous papers—some of them supporting the condensation theory, some opposing it, and some taking an intermediate attitude. Although this revived condensation theory never gained much support, it has persisted to the present. In 1921, Ototzky,[14] the well-known Russian hydrologist, stated that the theory of infiltration has no solid scientific basis, and that infiltration of atmospheric precipitation occurs to a considerable depth only in exceptional circumstances and in restricted areas. He mentioned condensation as an important factor in ground-water recharge.

The scientific basis of the infiltration theory.—In spite of these apparent flarebacks, the infiltration theory has become firmly established. The work done in the United States alone has, it seems to me, conclusively demonstrated that the ground water is derived mainly from rain and snow. The demonstration consists of abundant care-

[14] Ototzky, P. *Underground water and meteorological factors.* Roy. Meteorological Soc. Quart. Jour., pp. 47–54, 1921. (Translated from the French by L. D. Sawyer.)

fully analyzed and substantiated data as to the seepage losses from streams, the downward penetration of the rain and snow water through the soil and subsoil, the rise of the water table in response to the flow of influent streams and in response to rainfall and melting snow, the slope of the water table from the demonstrated intake areas to the areas of ground-water discharge, the relation of the quantity of ground-water discharge in any area to the mean annual precipitation and to the permeability of the intake materials, and the fluctuation of discharge with fluctuations in precipitation.

The evidence that has been least conclusive is that regarding rainfall penetration, whether derived from lysimeter tests or from moisture determinations of soil borings. Negative conclusions regarding rainfall penetration have been reached, partly because inadequate methods were used and partly because it was not fully appreciated that, in spite of many negative results, there may be great recharge in certain localities of permeable material by confluence of rain water in periods of exceptionally heavy precipitation. We now have evidence that soil moisture may be moving downward to the water table, in large aggregate amounts, without any of it dripping into an ordinary lysimeter and without a large increase at any time in the moisture content of the material below the "root zone." A group of investigators in the U. S. Bureau of Agricultural Engineering, the U. S. Geological Survey, and the California Division of Water Resources are now engaged in critical studies of rainfall penetration, and are, I believe, placing this subject on a sounder scientific basis than it has hitherto had.

Before leaving the subject of the origin of the ground water, reference should be made to the theory of juvenile water, which was developed by Edward Suess,[15] and the theory of connate water, which in this country was developed chiefly by Alfred C. Lane. These theories supplement rather than conflict with the infiltration theory, and they can not properly be regarded as having any real relation to the old condensation and sea-water hypotheses.

THE RISE OF GEOLOGY AND ITS APPLICATION TO GROUND WATER

Geology affords the framework on which ground-water hydrology is built; more accurately, it describes the rock formations that make up the great and intricate systems of natural waterworks, the func-

[15] Suess, Edward. *Über heisse Quellen.* Gesell. deutsch. Naturf. und Aertze Vortr. pp. 133–150. 1902.

tioning of which forms the essential part of the subject of ground-water hydrology. Therefore, although earnest attempts were made by Vitruvius and others to give useful information as to the water-bearing properties of different rocks, the subject of ground-water hydrology could not be far developed until the fundamental principles of geology were established near the close of the 18th century.

One of the first men to apply geology, in the modern sense, to the problems of ground water was William Smith[16] (1769–1839), who has been called the Father of English Geology. Although Smith was deeply interested in geology for its own sake, he was even more interested in the fact that as a civil engineer he was able to apply his knowledge of the new science to engineering problems and to the development of mineral and water resources. Although he never wrote a treatise on any phase of the subject of ground water, he was greatly interested in the application of geology to ground-water problems. His notes show that he was interested in wells and springs, not only because they furnished clues as to the stratigraphy and structure, but also because of their value in determining the ground-water conditions.

Of special interest is Smith's development of a water supply for Scarborough, described in a paper published in 1827, because of its thoroughly modern attitude in regard to the conservation of ground water. Obtaining his clues from an old flowing well, he located a water-bearing sandstone, worked out its boundaries and structure, estimated its yield per foot of drawdown, and then built a subsurface dam whereby the water was impounded in the sandstone during the wet winter season and withdrawn through a pipe by gravity in the summer. In regard to this project Smith wrote with much enthusiasm:

> This reservoir, wholly unseen, made at my suggestion in the hills at a trifling expense, to pen up in the rocks 5,000 hogsheads of water, is by far the most curious and perhaps the most useful practical hint hitherto deduced from Geology. So far, I think I was never in my life more usefully employed.

GROUND-WATER HYDROLOGY IN EUROPE IN THE 19TH CENTURY

In the first half of the 19th century, the French engineers, geologists, and drillers took the lead in the study of ground water, largely because there was intense interest in the artesian conditions and the great activity in drilling artesian wells during that period in France. About the middle of the century there appeared a number of publications, chiefly in France, based on extensive research in different

[16] SHEPPARD, THOMAS. *William Smith, his maps and memoirs*, Hull, 1920.

phases of the subject of ground water, and it should perhaps be considered that ground-water hydrology, as a branch of science, had its beginning at this time. I refer especially to the work of the following men: The engineer Eugène Belgrand (1810–1878), who in the first of his many works, published in 1846, made the fundamental distinction between permeable and impermeable formations as applied to ground water;[17] the German chemist Karl Gustav Bischof (1792–1870), the results of whose work on ground water are given in his text-book of chemical and physical geology published about 1847; Jules Dupuit[18] (1804–1866), whose work[19] on the movement of ground water was published in 1848; the Abbé Paramelle[20] (1790–1875), whose treatise on ground water was published in 1856; Jean Dumas[21] (1800–1884 ?), whose "La science des fontaines" was published in 1857; the hydraulic engineer Henri Darcy[18] (1803–1858), often called the founder of the science of hydrology, the first results of whose experiments on the laws of flow of ground water were published in 1856 in a work with the modest title "Les fontaines publiques de la ville de Dijon"; and Henri Bazin, who was associated with Darcy but active into the present century.

Two notable workers in ground water in a little later period were the French geologist Gabriel Auguste Daubrée (1814–1896), and the German hydrologist Adolph Thiem (1836–1908). Daubrée made a large and valuable contribution to the subject of the relation of geologic structure to the occurrence and movement of ground water. His principal results[22] were published in three large volumes in 1887. Thiem was the pioneer of intensive ground-water work in Germany. He introduced field methods for making tests of the flow of ground water and applied the laws of flow in developing water supplies. Under his influence Germany became the leading country in supplying

[17] BELGRAND, EUGÈNE. *Étude hydrologique de la partie supérieure du Basin de la Seine*, 1846. For a list of Belgrand's principal publications, from 1846 to 1882, see MAGER, *op. cit.*, pp. 13, 14. For an estimate of his work see also POCHET, LÉON. *Études sur les sources.* **1**: 3–5. 1905.

[18] For an estimate of the work of Dupuit and Darcy see KELLER, HERMANN. *Gespannte Wässer.* Halle, p. 9. 1928.

[19] DUPUIT, JULES. *Études theoriques et pratiques sur le mouvement des eaux courantes*, Paris, 1848; also *Traité de la conduite et de la distribution des eaux*, Paris, 1854.

[20] For sketch of Paramelle's life and estimate of his work see MAGER, *op. cit.*, pp. 9–13.

[21] For estimate of Dumas' work see MARTEL, *op. cit.*, p. 79; KELLER, *op. cit.*, p. 9.

[22] DAUBRÉE, A. *Les eaux souterraines a l'époque actuelle et aux epochues anciennes*, 3 vols., Paris, 1887. For estimates of Daubrée's work see ZITTEL, K. A., *Geschichte der Geologie und Palaontologie bis Ende des 19 Jahrhunderts*, p. 304, 1899. (English translation by M. M. Ogilvie-Gordon, pp. 200–202, 1901. POCHET, *op. cit.* p. 3; MAGER, *op. cit.*, pp. 18–20.

the cities with ground water.[23] The results of his work appeared in a number of papers, the first in 1870.[24] Mention should also be made of the Italian hydrologist, D. Spataro.[25]

GROUND-WATER HYDROLOGY IN THE UNITED STATES IN THE 19TH CENTURY

In the United States not much systematic ground-water work was done before 1873. In 1856, George G. Shumard made a brief report on artesian prospects on the Llano Estacado for the Pacific Railway survey, which was not published until 1892. In 1857, the New Jersey Geological Survey published the "Geology of the county of Cape May," by George H. Cook, which included a brief discussion of the artesian conditions. Later reports of the New Jersey Geological Survey contain considerable information on the artesian waters of the State by Lewis Woolman and others. In 1859, W. W. Mather published a report on certain artesian wells in Ohio. Some early work on artesian conditions was also done at New Orleans, Charleston, S. C., and in other parts of the country. From 1873 to 1879, in connection with the Geological Survey of Wisconsin, Thomas C. Chamberlin made a thorough study of artesian conditions in Wisconsin. His principal report on the artesian wells was published by the State survey in 1877; his well-known paper, "The requisite and qualifying conditions of artesian flow," was published by the U. S. Geological Survey in 1885.

In 1881, C. A. White and Samuel Aughey were appointed by the Secretary of Agriculture as a geological commission to investigate the artesian prospects of a portion of the Great Plains. Their brief report, published in 1882, contains only meager data and very general conclusions.

On March 27, 1890, Major J. W. Powell,[26] Director of the United States Geological Survey, presented before the Committee on Irrigation of the House of Representatives a remarkably interesting and informative statement on the artesian conditions and prospects in the arid regions of the United States. This statements shows that considerable ground-water work had already been done and that some

[23] For estimate of Thiem's work see KELLAR, *op. cit.*, pp. 9, 10.

[24] THIEM, ADOLPH. *Über die Ergiebigkeit artesische Bohrlöcher, Schachtbrunnen, usw.*, 1870. For a list of some of Thiem's later publications see SLICHTER, C. S. *Theoretical investigations of the motion of ground water.* U. S. Geol. Survey Nineteenth Ann. Rept., pt. 2, p. 384, 1898.

[25] SPATARO, D. *Storia dell'acqua e Idrografia sotterranea d'Italia*, Milan, 1891.

[26] POWELL, Major J. W. U. S. Geol. Survey Eleventh Ann. Rept., pt. 2, pp. 260–278. 1891.

of the main features of the ground-water conditions of the country were already understood. Major Powell's summary shows a masterful grasp of the situation and his conclusions have stood the test of time.

On April 4, 1890, an act was approved which authorized the Department of Agriculture to make investigations to determine the location for artesian wells west of the 97th meridian and east of the Rocky Mountains. Colonel Edwin S. Nettleton, irrigation engineer of the Department of Interior, was placed in charge of the field work, Robert Hay was appointed chief field geologist, and a number of other leading geologists were employed. As Congress directed that a report must be made immediately after July 1, only 60 days were allowed for making the investigation, and on August 20, 1890, the Secretary of Agriculture transmitted a voluminous report which contains much loosely-assembled information on the artesian conditions of the extensive region covered, and numerous records of head and discharge that have acquired peculiar value in showing the approximate original artesian conditions. With subsequent appropriations and extensions of time, the investigation was continued and the results were published in 1891 and 1892 in several volumes that contain a large amount of information. One of the geologists of this Survey was Robert T. Hill, who, I believe, has the distinction of being the first to recognize, in his report published in 1892, the importance of the water in the valley fill.

About this time great interest developed in ground water, not only in the arid regions but also in the more humid sections of the country, and many ground-water investigations were undertaken, chiefly by the United States Geological Survey. Thus in the last decade of the 19th century a group of eminent American geologists directed their attention to ground water and published comprehensive and thoroughly sound areal reports on the subject. Let us call the roll of these geologists in the order in which their first publications on ground water appeared[27]: Robert T. Hill, W J McGee, Israel C. Russell, Nelson H. Darton, Robert Hay, Grove K. Gilbert, Frank Leverett, Warren Upham, George H. Eldridge, William H. Norton, T. Wayland Vaughn, Edward Orton, S. W. McCallie, and Willard D. Johnson. The largest part in this early work was taken by Darton. Near the close of the century notable work was also done on the hydrologic

[27] For references to the first and subsequent publications on ground water by these geologists, see NICHOLS, J. M. *Geologic literature of North America 1785–1918, Pt. 1, Bibliography.* U. S. Geol. Survey Bull. **746**: 1923.

phases of the subject of ground water by three eminent American investigators: Allen Hazen,[28] Franklin H. King,[29] and Charles S. Slichter.[30]

GROUND-WATER HYDROLOGY IN THE 20TH CENTURY

From the beginning of the 20th century to the present time there has been increased activity in the study of ground water, with more workers than in any earlier period, and consequently a rapidly increasing literature and a differentiation of the subject along a number of specialized lines. This activity may to some extent be judged by the considerable number of comprehensive treatises that have appeared on the subject, most of them the products of many years of ground-water investigation by the authors. I do not feel qualified to select the leaders in this recent period, but I will mention a few representative workers, all of whom made substantial contributions.

Among the French my attention has been called especially to the work of the following men: Léon Pochet, Edmond Maillet, F. Diénert, Louis Dollé, Edouard Martel, and Edouard Imbeaux. Both Pochet[31] and Maillet[32] published treatises in 1905 on the hydraulics of ground water. Martel has studied especially the occurrence and movement of water in cavernous limestone, and has also published a treatise, already cited, on the general subject of ground water. Imbeaux since 1886 has published extensively on the subject of ground water, including a large recent work on "hydrogeology," already cited. Dr. Imbeaux has the distinction of being the Chairman of the Commission on Underground Waters in the Association of Scientific Hydrology of the International Union of Geodetics and Geophysics.

Among the ground-water hydrologists of Germany I may mention, in alphabetical order E. Ebermayer, A. Grund, A. Hertzberg, K. Keilhack, H. Keller, W. Koehne, O. Luegar, E. Prinz, L. Reuter, M. Rother, W. Salmon, A. Steuer, G. Thiem, and R. Weyrauch. These and other German hydrologists have produced a large and valuable

[28] Annual Reports of Mass. State Board of Health, 1892 and 1893.

[29] King, Franklin H. *Observations and experiments on the fluctuations in the level and rate of movement of ground water on the Wis. Agri. Exper. farm.* U. S. Weather Bur. Bull. **5**: 1892. *Principles and conditions of the movements of ground water.* U. S. Geol. Survey 19th Ann. Rept. Pt. 2, pp. 59–294. 1899.

[30] Slichter, Charles S. *Theoretical investigation of the motion of ground water.* U. S. Geol. Survey 19th Ann. Rept. Pt. 2, pp. 295–384. 1899.

[31] Pochet, Léon. *Études sur les sources. Hydraulique des nappes aquifères et des sources et applications pratiques,* 2 vols., Paris, 1905.

[32] Maillet, Edmond. *Essais d'hydraulique souterraine et fluviale,* Paris, 1905.

literature on the subject. Among the outstanding productions are the general treatises by Prinz,[33] Keilhack,[34] and Koehne.[35]

I am not familiar with the literature of Italy, but the high rank of that country in ground-water work can in some degree be judged by the fact that a bibliography prepared by Michele Gortani[36] lists about one thousand publications on the ground-water hydrology of Italy between 1870 and 1923. Outstanding names are perhaps those of G. Cuppari and M. Canavari.

Much valuable work has also been done in other European countries. I may mention in Russia, P. Ototzky and Alexander Lebedief; in Austria, Hans Höfer-Heimhalt,[37] P. Forchheimer, O. Smreker, U. Huber, and Charles Terzaghi; in Holland, Eugène Dubois, J. Pennink, and J. Versluys; in Belgium, René D'Andrimont; in Switzerland, Albert Heim, T. Hug, and Arnold Engler; in Sweden, J. Richert; in Denmark, Hilmar Odum; and in Spain, Bartotomü Darder Pericás, who recently published a treatise on investigations of ground water.

The British hydrologists have been active in making areal ground-water surveys and in developing ground-water supplies but have perhaps contributed less notably to the science of ground-water hydrology. Outstanding names in this field are those of Horace B. Woodward[38] and William Whittaker, author of numerous areal ground-water reports for the Geological Survey of Great Britain. Much ground-water work has been done in Australia, India, and other parts of the British Empire; also in other parts of Asia and Africa, in the Latin American countries, and in the uttermost parts of the earth. Most of this work has, of course, been descriptive, but some critical investigations have been made, especially in India.

Beginning with the 20th century and extending to the present time, a large amount of ground-water work has been in progress in this country. Most of it has been done by the staff of the United States Geological Survey, but much has also been contributed by many other workers, especially in California. Since 1900 the Geological Survey has published more than 300 papers, in about 190 volumes,

[33] PRINZ, E. *Handbuch der Hydrologie.* Berlin, 1st ed. 1919, 2nd ed. 1923. Contains bibliography which lists the principal publications of the hydrologists mentioned and of other European hydrologists.

[34] KEILHACK, K. *Op. cit.*, 1st ed. 1912, 2nd ed. 1917, 3rd in preparation.

[35] KOEHNE, W. *Grundwasserkunde.* Stuttgard, 1928.

[36] GORTANI, MICHELE. *Saggio bibliografico dell'idrologia sotteranea d'Italia dal 1870 al 1923.* Giornale di Geologia Pratica, **19**: 1924. Contains also introduction concerning Italian ground-water work.

[37] *Grundwasser und Quellen*, Braunschweig, 1912; 2nd ed., 1920.

[38] WOODWARD, HORACE B. *The geology of water supply.* London, 1910.

that relate primarily to ground water. These publications are largely descriptive and areal, but altogether they unquestionably make a large contribution to the science of ground-water hydrology.[39] To Walter C. Mendenhall, I believe, belongs the chief credit for beginning systematic quantitative investigation, which has become characteristic of our work in this country.

DEVELOPMENT OF DIFFERENT BRANCHES OF THE SCIENCE

Investigations of artesian principles.—Let us now make a rapid survey of the development of some of the different branches of ground-water hydrology. Artesian wells have been in existence since ancient times, and were of great interest not only because of the spectacular phenomenon of natural overflow but also because of the wholesome water which they furnished at a time when most water supplies were badly polluted. According to Keilhack, the Egyptian oases were supplied by numerous artesian wells as early as 2,000 B.C.; and Keilhack, like some of the other authorities, believes that Moses learned the art of well drilling from the Egyptians. The study of artesian water naturally came next in historical development to that of the origin of springs. Even before the emergence of geology, the basic principles of artesian pressure were understood. Pioneers in the development of the hydrostatic theory of artesian pressure were the Italian astronomer and geographer Giovanni Cassini (1625–1712), and the Italian physician Bernardini Ramazzini, whose best-known publication appeared in 1691. In the first half of the 19th century, the French were active, not only in drilling artesian wells and improving drilling methods, but also in developing the principles of artesian pressure and in making geologic applications of them in locating artesian water. During this period the hydrostatic theory became well established.

Chamberlin's paper published in 1885 is a clear, accurate, and critical statement of the general subject of artesian conditions, based largely on his own field studies. Very modestly he stated that it was not an exhaustive exposition of the subject and did not contain much that was original. He did his work so well, however, that the subsequent prevailing attitude, at least in this country, was one of complacent assumption that the principles of the subject were completely

[39] See Water-Supply Paper **427** for U. S. Geological Survey publications relating to ground water up to 1918, and the Survey's list of publications for later papers. Publications on ground water since 1928 are listed in the semi-annual volumes of Annotated bibliography of economic geology (prepared under the auspices of the National Research Council)

mastered. This attitude was challenged by M. L. Fuller in 1908 in his paper, "Summary of the controlling factors of artesian flows."[40] We now recognize that the hydrology of artesian water is a complicated subject that offers a large field for further investigation. Until recently attention has been directed mainly toward the static or structural conditions, with neglect of the hydraulics or dynamics of artesian water, although Chamberlin recognized what we may perhaps call the dynamic principle, and, indeed, considered that his original contribution lay in the recognition of this principle.

Rock pressure was assumed by Thales about 650 B.C., and later by Pliny, as the agency for elevating the sea water to the levels of the springs. In modern times rock pressure has been suggested by different investigators as a cause of artesian head, and there has been unprofitable argument between the champions of this theory and the defenders of the orthodox hydrostatic theory. Recent critical interpretation of the behavior of wells has led us to recognize that the artesian water supports a part of the load of the overlying rocks and that many of the water-bearing formations have measurable elasticity; however, this concept of rock pressure supplements the hydrostatic theory without displacing it.[41]

Development of the principles relating to water tables and pressure-indicating surfaces.—The concepts of the zone of saturation and of the water table, as the upper, free-water surface of that zone, developed later than the concept of the artesian basin. In a sense the early scientific thought on ground water was deficient with respect to the third dimension. It was generally considered that the water from the surface percolates downward till it reaches an impermeable bed and then percolates laterally over the upper surface of that bed to its outcrop. This concept was amplified by the recognition of artesian structures in which the water becomes confined between two impermeable beds. More recently the concept has been developed, step by step, of a zone of saturation, with large storage capacity, performing the functions both of a huge reservoir and of a very intricate system of conduits.

The simple concept of the water table has developed rather tardily, although a good contour map of the water table was published by Gustave Dumont[42] in 1856. Gradually we are coming to recognize the

[40] Fuller, M. L. U. S. Geol. Survey Bull. **319:** 1908.

[41] Meinzer, O. E. *Compressibility and elasticity of artesian aquifers.* Econ. Geol. **23:** 263–291. 1928.

[42] Dumont, Gustave. *Les eaux alimentaires de la ville de Liége,* 1856.

significance of the form of the water table, with respect to intake, movement, and discharge of the ground water, with the resulting sanitary applications; and of its fluctuations in response to devious processes of accretion and withdrawal of the ground water. We now recognize that there may be two or more separate zones of saturation above one another, each with a normal water table, and that where an impermeable body occurs between a zone of saturation and an overlying zone of aeration there can be no water table or anything that functions like a water table.

Gradually we are gaining a better concept of the zone of saturation itself, recognizing that it may include diverse geologic formations, with all of the intricate stratigraphy and structure that the geologist recognizes and much more that is beyond the reach of the present methods of geology but may nevertheless produce pronounced effects on the behavior of the water. We now recognize that as a result of the rock structure the water in the zone of saturation is everywhere under a pressure gradient, which is not a simple linear affair, as in ordinary hydraulics, but is three-dimensional, and that the ground water is everywhere moving in the direction of the gradient, chiefly along the strata, either up or down the dip, but also upward or downward across the strata.

The concept of the pressure-indicating surface, or piezometric surface, has been recognized for a considerable time, and contour maps of such surfaces have been made for several decades. Recently we have come to recognize more clearly that these surfaces are functionally different from the water table, and that for any zone of saturation, with its single water table, there may be a series of piezometric surfaces each representing a different ground-water horizon. The French have distinguished between the niveau des eaux (water table) and the niveau piezometric; while the Germans have used the term Grundwasserspiegel (ground-water mirror) to designate the water table, and have used for the other concept the French term Piezometrisches Niveau, or some German term such as Wasserdruckschicht.

As in most other fields of ground-water hydrology, the foundations in this field have been laid by the European investigators.[43] Apparently, however, the United States has now taken the lead in this line

[43] Veatch, A. C. *Fluctuations of the water level in wells, with special reference to Long Island, N. Y.* U. S. Geol. Survey Water-Supply Paper **155**. 1906. This paper gives much information and many references relating to the developments of parts of this subject prior to 1906.

of investigation. The automatic water-stage recorder is coming to be our principal instrument of precision in ground-water work. It promises to make ground-water hydrology a more exact science and may prove to be of value in the study of geologic structure.

Investigations of the relation between fresh and salt water.—The law of equilibrium between sea water and fresh ground water under non-artesian conditions was discovered by the Dutch engineer, Badon Ghyben, and was announced by him in a paper in the Dutch language in 1887. It seems to have been independently rediscovered about 1900 by Herzberg, of Berlin. This important subject has been further developed by a number of Dutch, Belgian, and German investigators already cited. The principles produced by the European workers were introduced into American ground-water work by Walter E. Spear and John S. Brown,[44] and have been effectively applied in the Coastal Plains of the United States proper and in the Hawaiian Islands, under both artesian and non-artesian conditions.

Investigations of the movement of ground water.[45]—About 1843 J. Poiseuille, in connection with his studies of the circulation of the blood, discovered the law of flow through capillary tubes—namely, that the rate of flow is proportional to the hydraulic gradient. In 1856, Darcy verified this law and demonstrated its application to water percolating through sand. In the 75 years since Darcy's results were published, many laboratory investigations of various phases of the problem of the flow of liquids and gases through permeable materials have been made.[46] About 1899 King reinvestigated the whole subject; a little later Slichter tested Darcy's law with lower hydraulic gradients than had previously been used, in order to approximate natural conditions more closely; and in 1923, in the hydrologic laboratory of the Geological Survey, tests were made under hydraulic gradients as low as 5 feet to the mile.[47] The results of the work subsequent to that of Poiseuille and Darcy support essentially the correctness of the law known as Darcy's law.

[44] SPEAR, WALTER E. *Report on water supply from Long Island sources.* Bd. of New York City Water Supply. **1**: 149–157. 1912.
BROWN, JOHN S. *A study of coastal ground water, with special reference to Connecticut.* U. S. Geol. Survey Water-Supply Paper **537**: 1925. Contains bibliography and digest of American and foreign literature on coastal ground water.

[45] For more detailed statement of the development of this subject, with numerous references to publications, see MEINZER, O. E. *Methods of estimating ground-water supplies.* U. S. Geol. Survey Water-Supply Paper **638**: 126–140. 1931.

[46] For review of this subject to close of 19th century by King and bibliography by Slichter see U. S. Geol. Survey, Nineteenth Ann. Rept. Pt. 2.

[47] STEARNS, NORAH D. *Laboratory tests on physical properties of water-bearing materials.* U. S. Geol. Survey Water-Supply Paper **596**: 152–159. 1927.

The pioneer in developing field methods for measuring the flow of ground water was Adolph Thiem, whose first paper on the subject was published in 1879. His method was to dig two test wells approximately in line with the direction of the movement of the ground water as determined from the slope of the water table, then dose the upper well with salt and at suitable intervals take samples from the lower well which he tested for their chloride content. A notable advance was made by Slichter in 1901 when he devised the electrolytic method.

In 1906 Günther Thiem,[48] son of Adolph Thiem, published his paper describing the field method for determining permeability and rate of flow from a pumping test and the resultant drawdown in observation wells. This method is now used in the United States and is being further investigated and developed by the Geological Survey.[49] More recently we have developed in this country, chiefly through the work of David G. Thompson,[50] a rating-curve method, by which an empirical relation is established between head and inflow, in areas in which ground water is extensively used.

Dye tests were made by Doctor Dionis, in France, in 1882, during an epidemic of typhoid fever, and since that time frequent use has been made of dyes, chiefly in sanitary investigations, to trace underground streams, such as occur in limestone.[51] In 1921 dye was used by Charles W. Stiles[52] and his associates in connection with an investigation at Fort Caswell, N. C., which involved a minute 3-dimensional survey of the direction and rate of movement of the ground water in a sand formation.

Molecular physics in relation to ground-water hydrology.[53]—The two principal forces that control the water in the rocks are gravity and molecular attraction. Many rocks have only very small interstices, and in these the molecular forces become effective. Indeed, the influ-

[48] Thiem, Günther. *Hydrologische Methoden,* Leipzig, 1906.

[49] Wenzel, L. K. *Recent investigations of Thiem's method for determining permeability of water-bearing materials.* Amer. Geophysical Union Trans., pp. 313–317. 1932.

[50] Thompson, David G. *Ground-water supplies of the Atlantic City region.* N. J. Dept. of Conservation and Development Bull. **30**: 35–88. 1928.

[51] For historical development and bibliography of this subject see Dole, R. B. *Use of fluorescein in the study of underground waters.* U. S. Geol. Survey Water-Supply Paper **160**: 73–85. 1906.

[52] Stiles, C. W., Crohurst, H. R., Thompson, G. E., and Stearns, N. D. *Experimental bacterial and chemical pollution of wells via ground water, with a report on the geology and ground-water hydrology of the experimental area at Fort Caswell, N. C.* U. S. Pub. Health Service Hygenic Lab. Bull. **147**: 1927.

[53] For more detailed statement of the development of this subject, with numerous references, see Meinzer, O. E. *The occurrence of ground water in the United States, with a discussion of principles.* U. S. Geol. Survey Water-Supply Paper **489**: 2–101. 1923.

ence of molecular attraction makes the hydraulics of ground water a quite distinctive subject.

Investigations of capillarity in water-bearing materials were made about 250 years ago by Perrault, who established the limits of capillarity in sand and showed that water absorbed by capillarity can never form accumulations of free water at higher levels. Since Perrault's time the occurrence and movement of water under molecular forces in soils and other fine-grained materials have been studied by many investigators in different countries and for a variety of purposes. Among the distinguished early investigators in this field in the United States, in the order in which their first important publications appeared, are Eugene W. Hilgard, 1860; Franklin H. King, 1892; Allen Hazen, 1893; and Lyman J. Briggs, 1897. Many other investigators in this field in both the United States and Europe might be mentioned, most of them belonging to the present century. Thus the results of much critical investigation have become available for the uses of hydrology. In the hydrologic laboratory of the United States Geological Survey we are now proceeding with the comprehensive project of determining the mechanical composition, porosity, moisture equivalent, and permeability of a group of samples from every water-bearing formation in the United States that is amenable to laboratory methods.

In our quantitative studies of intake, discharge, and safe yield of ground water, we are vitally concerned with the mechanical composition and porosity of water-bearing materials, the capillary fringe, the capillary potential and the laws of capillary movement of water, the specific retention, the specific yield and other varieties of effective porosity, and the moisture equivalent, wilting coefficient, and hygroscopic coefficient; we are eager to cooperate with the soil physicists and agricultural engineers in all investigations that involve the moisture properties of fine-textured materials. It appears that the European literature on ground water is somewhat defective in respect to molecular physics and that the American hydrologists are making a definite contribution in cultivating this field.

Investigations of discharge of ground water.—Ground water is discharged by two processes: the hydraulic process, or discharge through springs; and the less conspicuous but equally important process of evaporation—both evaporation directly from the soil and transpiration of plants in areas having a shallow water table.[54]

[54] For more detailed historical statement and references to the literature regarding discharge of ground water by transpiration see MEINZER, O. E. *Plants as indicators of ground water.* U. S. Geol. Survey Water-Supply Paper **577.** 1927.

The complex subject of the geologic and hydraulic conditions that produce springs was one of the first fields of ground-water hydrology to receive attention and has been given much study. Fluctuations in the flow of springs and of streams at low stages was given critical study about the beginning of this century by Maillet, with the purpose of developing methods of forecasting their flow. He mentions a number of investigators of this subject, dating back to 1863. The subject has also received some attention in this country, by Arthur C. Veatch and others. On account of the drought of 1930, new interest has recently been developed in this subject, and considerable investigation has been started, especially as to the relation of the water table to the discharge of springs and to the ground-water run-off.

The subject of the discharge of ground water by transpiration of plants and evaporation from the soil has until recently not received much attention either in Europe or in the United States, for the reason that these processes are not readily discerned in humid regions. One of the most curious defects of the early ground-water literature in this country is its silence on this subject. Even the geologists who worked in the arid West took with them the inadequate ideas acquired in the humid regions and failed at first to appreciate the magnitude of the ground-water resources of the arid regions because they did not understand the significance of ground-water discharge by transpiration and soil evaporation.

These processes are, however, conspicuous when once discerned in arid regions. When we consider the vast development of ground-water supplies in southern Asia and northern Africa in very ancient times, we must believe that knowledge of this subject, especially as to the significance of native plants as indicators of ground water, is also very ancient. Moses spent a large part of his life in stock-raising in a desert country, where he doubtless had numerous problems of water supply and abundant opportunity to observe the relation of the native vegetation to the occurrence of ground water. Later he was successful in the tremendous undertaking of furnishing water supplies in this desert country to a great host of people, doubtless because of his first-hand knowledge of ground-water conditions, including the significance of desert plants as indicators of ground water. Vitruvius had a knowledge of plant indicators and evaporation phenomena which he may have acquired by observations in arid regions. In his work on architecture he gave a list of plants that indicate ground water and endeavored to specify the conditions under which they may be regarded as reliable indicators. He also explained the process of

alkali accumulation by evaporation of ground water. Similar statements in regard to plant indicators are found in the writings of Pliny, who apparently quoted Vitruvius, and in those of Cassiodorus, in the sixth century, who obtained his ideas largely from an "aquilege," or professional water finder, who came to Rome from the arid regions of Africa. "Because of the great aridity of the terranes of his country," wrote Cassiodorus, "the art of discovering springs is there cultivated with the greatest care."

Vitruvius and the other Roman writers who have been mentioned discussed also less tangible methods of locating ground water, such as color and dampness of the soil, mists rising from the ground early in the morning, and sponges becoming moist when placed in shallow holes in the ground. Obviously these methods border closely on divining, or water-witching, and it is greatly to the credit of Vitruvius, Pliny, and Cassiodorus that none of them recognized divining or any other magical method for locating ground water. Although the means suggested by Vitruvius as aids in finding water may not have had much value, yet they were serious efforts to discover practicable methods at a time when the science of geology was still a complete blank.

That plants in general, and especially forest trees, draw upon the ground-water supply has been recognized by numerous authorities in recent times. Most of these have, however, not been much concerned as to whether the plants withdraw water from the zone of saturation or merely absorb the soil moisture before it reaches the water table, and they have not distinguished between different species in this respect. The relation of specific plant species to the water table was recognized by F. Amy in 1861, Frederick V. Coville in 1893, and the Danish ecologist Eugen Warming in 1895. The subject of plant indicators was treated at length by Henri Mager[55] in 1912, and references to plants that depend on ground water are found in many publications relating to arid regions.

In the last 25 years the geologists and hydraulic engineers who have worked on ground-water problems in the western part of the United States have given considerable study to evaporation of ground water and to the native plants that habitually feed on ground water, the depths to which the plants of each species will send their roots to reach ground water, and the quality of the water that they indicate. Tank experiments of the rate of discharge of ground water by capil-

[55] Mager, Henri, *Op. cit.*, pp. 310–319.

lary rise and subsequent evaporation were made by Slichter in 1905, Charles H. Lee in 1910, R. B. Sleight, in 1916, and other investigators more recently. In 1912 Lee[56] published the results of his investigations in Owens Valley, Calif., in which he made tank experiments of the rates of discharge of salt grass with different depths to the water table, and applied these rates to a map which he made of the salt-grass area showing depths to the water table. Since that time a number of investigations have been made in which areas of ground-water discharge have been mapped and rates of discharge have been applied thereto.

Daily fluctuations of the water table were observed by King in his experiments at Madison, Wis., in 1888, and he recognized their significance in recording the discharge of ground water through vegetation. The method was successfully applied by G. E. P. Smith, in Arizona, by the use of water-stage recorders on wells in 1917, in tracts of cottonwood and mesquite, and later also in tracts of salt grass and alkali sacaton. Smith also developed the theory of upward percolation and showed that the daily vegetal discharge could be computed from the rate of rise of the water table at the nocturnal mid-stage if the specific yield were known. More recently Walter N. White,[57] in his work in Escalante Valley, Utah, devised methods of evaluating the daily fluctuations in terms of quantity of water discharged, and developed the method of computing ground-water discharge from the dry weight of the principal phreatophytes.

INVESTIGATIONS OF THE CHEMISTRY OF GROUND WATER

I will not attempt to sketch the development of our knowledge of the mineral composition and chemical reactions of the ground water and of their relation to the occurrence, movement, head, and temperature of this water. Much good work has been done in this field, which involves chemistry, physics, and geology; but much remains to be done. Fortunately, we now have a chemical laboratory in the United States Geological Survey, devoted entirely to the investigation of the natural waters, in which, under the direction of W. D. Collins, are analyzed samples of water from practically all water-bearing formations in the United States, collected by the geologists who are investigating these formations.

[56] Lee, C. H. *An intensive study of the water resources of a part of Owens Valley, Calif.* U. S. Geol. Survey Water-Supply Paper **294**: 53–60. 1912.

[57] White, Walter N. *A method of estimating ground-water supplies based on discharge by plants and evaporation from soil; results of investigations in Escalante Valley, Utah.* U. S. Geol. Survey Water-Supply Paper **659**: 1–105. 1932. This paper contains a statement of the work of King and Smith.

The subject of the physiological effects of the natural waters is closely related to, rather than a part of ground-water hydrology. The subject is inherently so obscure that it lends itself to further befogging by pseudo-scientists. However, there is here probably a field for genuine research; at least, this is suggested by the discovery of the function of iodine in preventing goiter and the recent discovery by Margaret Smith[58] and her associates of the relation of fluorine to the puzzling affliction of mottled teeth.

INVESTIGATIONS OF THE BIOLOGY AND BACTERIOLOGY OF GROUND WATER

Considerable study has been given to the subject of living organisms in ground water, but less to the hydrologic conditions under which these organisms exist. Work on the occurrence, viability, and movement of bacteria in ground water has both sanitary and scientific significance, but is difficult because it must be done under aseptic conditions. Bacteria are introduced into wells by the drilling processes, and therefore great caution must be exercised in drawing conclusions as to the origin of bacteria delivered by wells, even when the samples are taken by the most approved methods. The Fort Caswell investigation, by Stiles and his colaborers, was exceptionally valuable because of the clear evidence that it produced of the viability and movement of *Bacterium coli* in a bed of water-bearing sand, under rigid bacteriological control and under definitely determined hydrologic conditions. However, the results have only limited application, and further work must be done before broad generalizations can safely be made.

STATUS AND PROSPECTS OF GROUND-WATER HYDROLOGY

It is evident, from the foregoing sketch of the history and development of ground-water hydrology, that although much effective work has in the aggregate been done in this branch of science, it is still in a formative condition, with relatively few workers, and with an impressive front of problems that are fairly begging for investigation. The main stimulus and support of ground-water hydrology has always been the human need for water supplies, and the glory of ground-water work has been that human betterment, through the development of more abundant, convenient, and wholesome water supplies, has followed close in the wake of our work. However, this

[58] SMITH, M. C., LANTZ, E. M., and SMITH, H. V. *The cause of mottled enamel, a defect of human teeth.* Univ. of Arizona Exp. Sta. Tech. Bull. **32**. 1931.

utilitarian urge has become so extreme that at present in this country practically all funds available for ground-water work must be used in applying our knowledge to specific ground-water surveys or water-supply problems, with virtually no opportunity for research work except as it is carried on inadequately and almost surreptitiously in connection with these utilitarian projects. We are constantly compelled to follow the wasteful course of applying the little that we now know instead of being able to devote a reasonable part of our efforts to the fundamental task of developing the basic principles of the science so that in the future we will have something more worth while to apply. What is primarily needed at present is not more money for ground-water work but a more rational use of the money that is spent.

The term hydrology has never come into such general use as might be expected in view of the magnitude and importance of the subject that it covers. This fact is in itself not of much consequence, but it is, I suspect, indicative of a real weakness that has pervaded the science, particularly in so far as it applies to the ground water. Certainly ground-water hydrology has suffered from the fact that the workers in the subject have largely been in two groups, inadequately correlated; namely, geologists, who have devoted their attention to the structure of the water-bearing formations without sufficient understanding of the laws of physics that govern the behavior of the water in them; and hydraulic engineers and physicists, who have studied the laws of fluid mechanics without sufficient knowledge of geology to apply their results effectively. It is doubtless desirable that we should continue to draw our recruits partly from the university departments of geology and partly from the schools of engineering, with smaller numbers from the departments of physics and chemistry. Moreover, it is evident that as the subject of ground-water hydrology develops, specialization within the subject will become increasingly necessary. However, to obtain the best results it is imperative that we recognize more largely that although hydrology is built on geology, physics and chemistry, it has a distinctive technique and subject matter, much as we recognize that the science of geology, although it is built on physics, chemistry, and biology, has its distinctive technique and subject matter.

While we recognize that ground-water hydrology is largely built on geology, we should also recognize that, conversely, a properly developed science of ground-water hydrology will be a substantial aid to geology, because the materials of geology are to a considerable extent the product of ground water. Geologists encounter many prob-

lems that involve ground-water hydrology, but frequently, because of the lack of a background in the subject, they are incompetent to deal effectively with these problems. The proximate reasons for this lack are obviously to be found in the textbooks of geology, most of which treat ground water only in a rudimentary if not amateurish manner, and in the university departments of geology, most of which have paid almost no attention to the subject. The more fundamental reason is doubtless to be found in the lack of organized subject matter that ground-water hydrology has had to offer. Courses devoted largely to ground-water hydrology are at present given at Harvard and in a few of the other universities. With the progress that is being made in the development of the subject, I believe it is safe to predict that before long no department of geology that undertakes to train graduate students will be considered complete unless it offers a course in ground-water hydrology, not merely as a branch of economic geology but as a part of the foundation upon which the training of a geologist must be built.

BOTANY.—*Hawaiian algae collected by Dr. Paul C. Galtsoff.*[1] MARSHALL A. HOWE, New York Botanical Garden. (Communicated by WILLIAM R. MAXON.)

Under date of March 28, 1932, William R. Maxon, Associate Curator, Division of Plants, United States National Museum, sent to the writer for study 23 jars of marine algae, collected in the summer of 1930 by Paul C. Galtsoff of the Bureau of Fisheries. Part of the specimens came from Kaneohe Bay, Oahu, and part of them were from the Pearl and Hermes Reef, which lies in the mid-Pacific Ocean approximately in North Latitude 27° 45′ to 28° and in West Longitude 175° 45′ to 176°. Most of the latter material was apparently obtained from a sand or "coral" bottom at depths of 2–67 ft. in water of temperatures ranging from 22.7°C. to 27.3°C. The Pearl and Hermes Reef lies more than 1200 miles northwest of Oahu, and it has been considered desirable to keep the two localities separated in the following list. So far as is known to the writer, no algae have hitherto been reported from the Pearl and Hermes Reef. However, a considerable number of algae, largely of plankton habitat, were collected in 1896 by H. Schauinsland on Laysan, which lies about 300 miles southeast of the Pearl and Hermes Reef. These were recorded in 1905 by E.

[1] Received August 31, 1933.

Lemmermann,[2] who listed 461 species and varieties of algae, chiefly plankton forms, from the Hawaiian Archipelago. These records and others were brought together by V. MacCaughey in 1918 in a paper entitled *Algae of the Hawaiian Archipelago.*[3]

ALGAE FROM KANEOHE BAY, OAHU, JULY, 1930

CHLOROPHYCEAE

DICTYOSPHAERIA CAVERNOSA (Forssk.) Børg.

Dictyosphaeria favulosa (Ag.) Dec.

DICTYOSPHAERIA VERSLUYSII Web. v. Bosse

This is distinguished from the preceding by having a solid thallus and by the numerous needle-like processes from the walls into the cell-cavities.

HALIMEDA DISCOIDEA Decaisne

Dredged in 13 ft. of water.

PHAEOPHYCEAE

HYDROCLATHRUS CLATHRATUS (Bory) M. A. Howe

Hydroclathrus cancellatus Bory.

TURBINARIA ORNATA (Turn.) J. Ag.

SARGASSUM ECHINOCARPUM J. Ag.

Sterile and without vesicles, leaves apparently broader (up to 10 mm.) than in the type and with more cryptostomata.

SARGASSUM POLYPHYLLUM FISSIFOLIUM Grun.

PADINA COMMERSONII Bory

DICTYOTA ACUTILOBA J. Ag.

Attached to *Sargassum polyphyllum fissifolium.*

RHODOPHYCEAE

Trichogloea subnuda sp. nov.[4]

Thallus strongly calcified (calcareous axis 0.75–1.6 mm. in diameter, the peripheral free layer about 0.2–0.3 mm. thick), 12–20 cm. long or high, irregularly 3–7 times subdichotomous and here and there subpinnate; outer cells of cortical filaments subglobose and ellipsoid to subpyriform, 9–21μ (mostly 13–18μ) broad, the terminal often smaller (10–12μ); cystocarps

[2] *Die Algenflora der Sandwich-Inseln.* Bot. Jahrb. **34:** 607–663, *pl. 7, 8.* 1905.

[3] Bot. Gaz. **65:** 42–57, 121–149.

[4] Fronde valde calcarea (axi calcareo 0.75–1.6 mm. lato, strato peripherico ca. 0.2–0.3 mm. crasso), 12–20 cm. alta, irregulariter 3–7-plo subdichotoma et passim subpinnata; cellulis filorum corticalium exterioribus subglobosis et ellipsoideis aut subpyriformibus, 9–21μ (plerumque 13–18μ) latis, apicalibus saepe minoribus (10–12μ); cystocarpiis subglobosis, 55–90μ in diam., involucro valde reducto, plerumque verticillo processuum uni- aut bi-cellularium uno constanti, in maturitate pro parte maxima occulto; monoica, antheridiis et procarpiis plerumque late remotis, aut aliquando dioica (?).

Specimen typicum in sinu "Kaneohe" dicto, insulae "Oahu" hawaiiensis, Jul. 1930, Paul C. Galtsoff legit. *Trichogloea lubrica* Butters, Minnesota Bot. Stud. **3:** 11–21. *pl. 5, 6,* 1903. Non *Trichogloea lubrica* (Harv.) J. Ag.

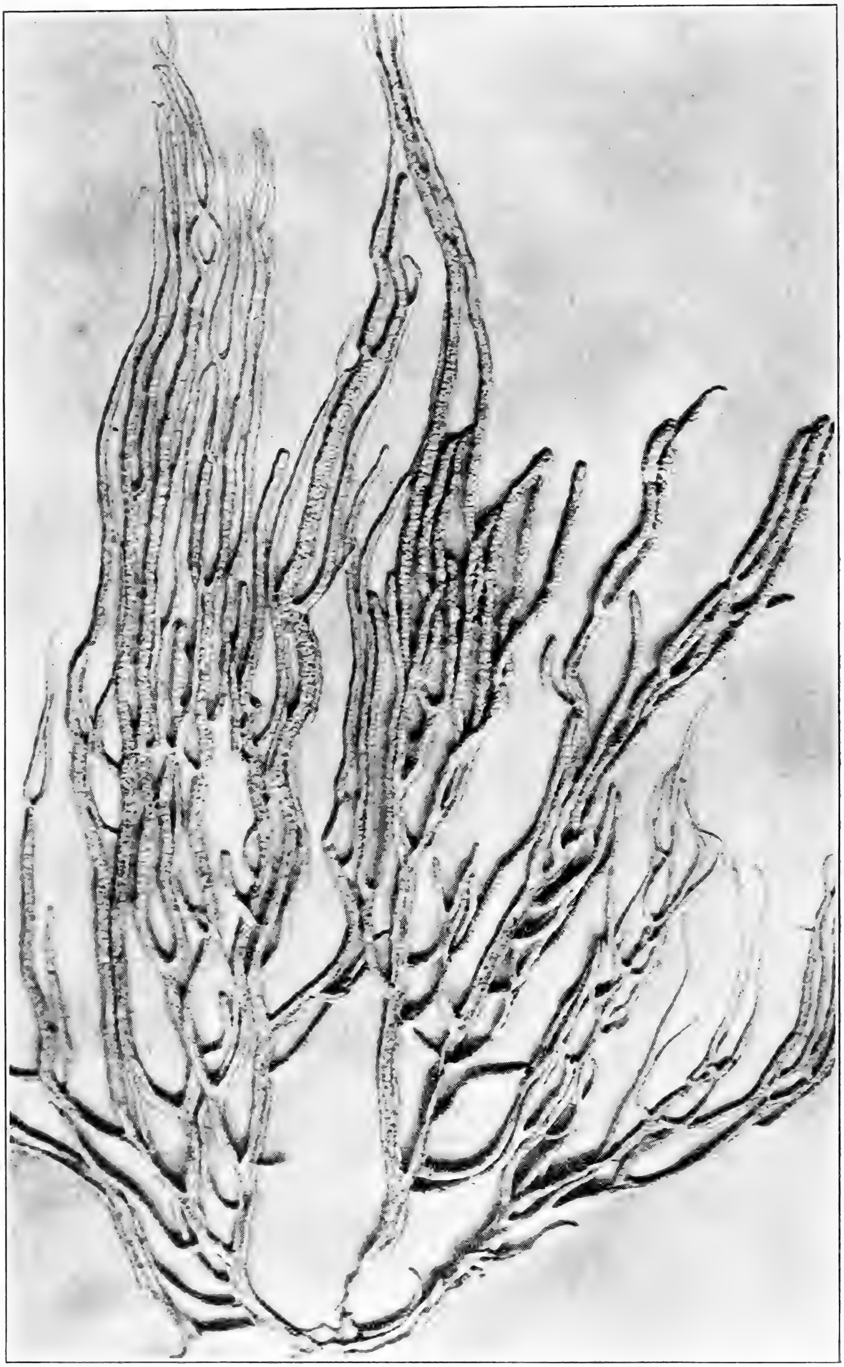

Fig. 1.—*Trichogloea subnuda.* More than half of the holotype dried from fluid-preserved material. Natural size.

subglobose, 55–90μ in diameter, the involucre very rudimentary, usually reduced to a single whorl of mostly unicellular excrescences, commonly concealed at maturity; apparently monoicous, with a somewhat wide separation of antheridia and procarps, and with a tendency to dioicism. [FIGURE 1.]

Type specimen collected in Kaneohe Bay, Oahu, by Paul C. Galtsoff, July, 1930. The holotype is divided between The New York Botanical Garden and the United States National Museum.

An excellent detailed description of *Trichogloea subnuda,* with illustrations, was published, under the name *Trichogloea lubrica* (Harv.) J. Ag., by F. K. Butters in 1903.[5] This description was based on fluid-preserved material, collected by Josephine E. Tilden, June 13, 1900, at Kahuku Point, Oahu. Dried specimens from the same collection were distributed as No. 419 of her American Algae, under the name *Nemalion ramulosum* Harv.

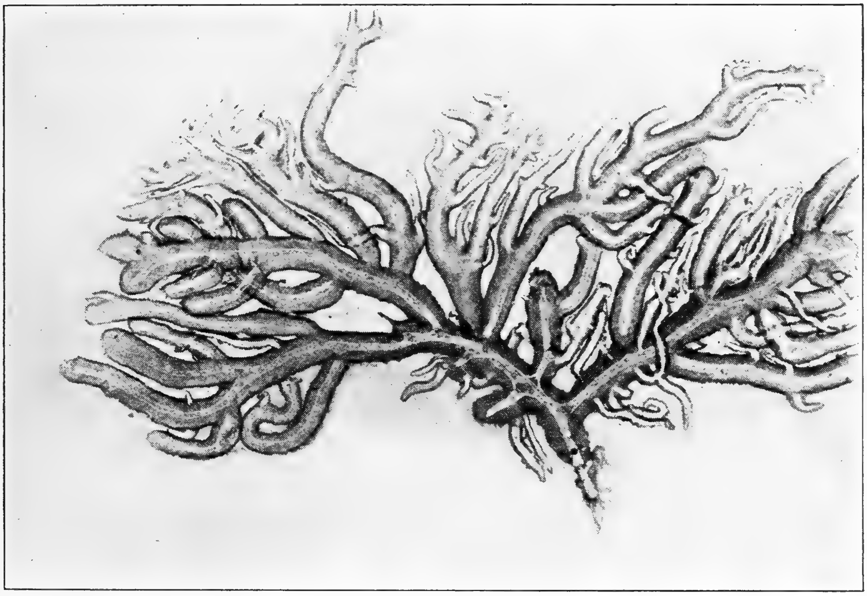

Fig. 2.—*Trichogloea lubrica.* Cotype in the British Museum. $\times\frac{2}{3}$.

This name belongs to a "species inquirenda" from New Zealand, the description of which, "fronde vermiformi compressa (2–3 lineas lata)" does not seem to fit the Hawaiian plant. Miss Tilden describes the color (which is lacking in Galtsoff's fluid-preserved specimen) as "brownish-red."

The drawing of specific lines in the genus *Trichogloea* is a bit difficult. The color, the size, the degree of calcification, the mode of branching, the size and form of the cells of the corticating filaments, and the monoicous or

[5] *Observations on* Trichogloea lubrica. Minnesota Bot. Studies. **3**: 11–21, *pl. 5, 6*, 1903.

dioicous distribution of the sexual cells all seem to be subject to considerable variation. The most stable characters are found in the cystocarp and more particularly in the development of the rudimentary pericarp just beneath it. The writer has enjoyed the privilege of examining the types, or at least authentic specimens, of all the species that have been referred to the genus. *Trichogloea subnuda* differs from all of them, or at least from the two legally published species, *Trichogloea lubrica* (Harv.) J. Ag. (type from Ooleva, Friendly Islands) and *T. requienii* (Mont.) Kütz. (type from the Red Sea), in the greatly reduced or vestigial character of the rudimentary involucre.

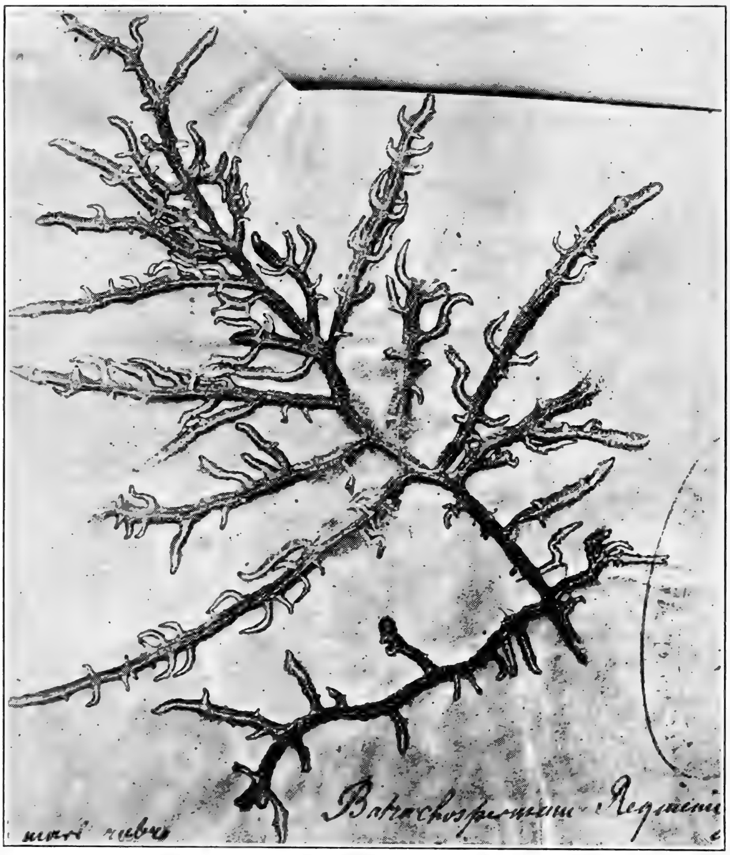

Fig. 3.—*Trichogloea requienii.* One of two original specimens in the Museum d'Histoire Naturelle, Paris. Natural size.

This consists commonly of a single verticil or pair of unicellular or two-celled excrescences or rudimentary bracteal filaments immediately below the auxiliary stalk-cell of the cystocarp. Rarely there is a one- or two-celled outgrowth from a lower cell (see Butters, *op. cit. f. 11, 13, 15,* and *16*). These

reduced bracts are nearly always wholly concealed by the development of the cystocarp. In *Trichogloea lubrica* and *T. requienii*, the cystocarp is subtended by a usually conspicuous rudimentary involucre, consisting of 3–5 whorls of simple or once or twice furcate filaments.[6] The cystocarps in these two species are dome-shaped, cylindric-dome-shaped, subconic, or occasionally subglobose, and 90–140μ in maximum diameter, while those of *Trichogloea subnuda* are subglobose and 55–90μ in diameter. Less stable distinctive characters of *Trichogloea subnuda* are found in its heavier calcification and its more dichotomous branching (compare FIGURES 1, 2, and 3).

Laurencia yamadana sp. nov.[7]

Frond spreading or reclinate, 5–7 cm. (or more?) high or broad, in branching irregularly 3 or 4 times compounded (or when pressed and dried, pseudo-tri-quadripinnate), the branches mostly divaricate, the primary

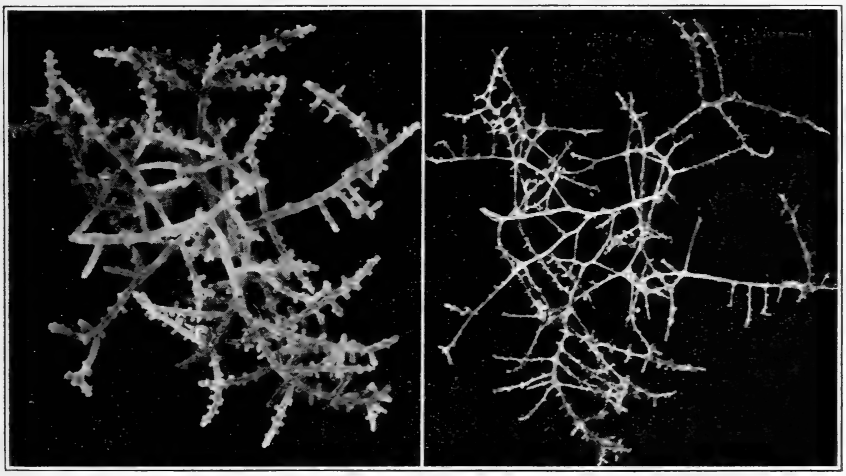

Fig. 4.—*Laurencia yamadana.* Holotype, left from fluid; right, same specimen dried. Natural size.

[6] See Okamura's representation of the cystocarp of *T. lubrica*, Icon. Jap. Alg. **4:** *pl. 197, fig. 6.* 1923.

[7] Fronde effusa aut reclinata, 5–7 cm. (an plus?) alta aut lata, irregulariter 3–4-ties compositi-ramosa (aut, compressa et exsiccata, pseudo-tri-quadripinnata), ramis plerumque divaricatis, primariis 2–4 cm. longis, ramulis ultimis clavatis obtusis et 2–3 mm. longis aut plerumque subtereti-turbinatis aut verrucaeformibus et 0.45–0.8 mm. longis, quoquoverse egredientibus, pro parte maxima spatiis suis longitudinibus aequalibus separatis; caulibus vel ramis primariis teretibus aut aegre compressa, circa 1–1.3 mm. crassa, cellulis superficialibus angulati-suborbicularibus, 20–45μ latis, in sectione transversali parum altioribus quam latis, denique saepe separantibus, ramulorum ultimorum cellulis superficialibus ovalibus aut subellipticis a superficie visis, 16–40μ in diam. max., parietibus crassis, in sectione transversali cellulis valliformibus, plerumque bis altioribus quam latis, aut in regione apicali ter altioribus; cellularum medullarium parietibus partes incrassatas non ostendentibus; partes aliae desunt.

Cum *Hypnea nidifica* J. Ag. consociatam, speciem *Laurenciae palisadae* Yamadae affinem, in sinu "Kaneohe" dicto, insulae "Oahu" hawaiiensis, Jul. 1930, Paul C. Galtsoff legit.

2–4 cm. long, the ultimate branchlets clavate-obtuse and 2–3 mm. long or mostly subterete-turbinate or verrucaeform and only 0.45–0.8 mm. long, emerging in various planes, for the most part separated by spaces equal to their own length; main axes terete or very slightly flattened, about 1–1.3 mm. in diameter, their surface cells angulate-suborbicular, 20–45μ in diameter, rather thin-walled, often separating, in transverse section slightly higher than broad; surface cells of ultimate branchlets often oval or subelliptic with longer axis transverse, 16–40μ in maximum diameter, thick-walled, in transverse section palisade-like, commonly twice as high as broad, or, in apical region, thrice as high; walls of medullary cells without lenticular thickenings; other parts wanting. [FIGURE 4.]

Apparently associated with *Hypnea nidifica*, near Wilcox wharf, Kaneohe Bay, Oahu, Paul C. Galtsoff, July, 1930. The holotype is divided between The New York Botanical Garden and the United States National Museum.

Laurencia yamadana belongs to Yamada's section Palisadae and is probably more allied to his *Laurencia palisada*[8] of Japan and Formosa than to his *L. intermedia* of Japan. It appears to differ from *Laurencia palisada* in its less distichous branching and in its shorter, more divaricate, and less capitate ultimate branchlets.

HYPNEA NIDIFICA J. Ag. Originally described from the Hawaiian Islands.

CHONDRIA TENUISSIMA (Good. & Woodw.) Ag., var. Apices of the ramuli are occasionally broad and obtuse as in var. *intermedia* Grun.

POLYSIPHONIA TONGATENSIS Harv.

ALGAE FROM PEARL AND HERMES REEF

CHLOROPHYCEAE

Microdictyon setchellianum M. A. Howe, nom. nov.

Microdictyon velleyanum, Univ. Calif. Pub. Bot. **14**: 561. *f. 85–92*. 1929. Not Decaisne, Arch. Mus. Paris. **2**: 116. 1841.

In 23 ft. of water, temp. 25.5°C., Pearl and Hermes Reef, Station 31, Galtsoff, July 23, 1930. Filaments 230–450μ broad. Only a few fragments, attached to a *Laurencia*.

The name *Microdictyon velleyanum* Decaisne was manifestly proposed as a substitute for Velley's *Conferva umbilicata* from New South Wales. The circumstance that Decaisne at the same time confused with it a very different plant from the Sandwich Islands does not alter the fact that, so far as the technicalities of publication are concerned, the name *Microdictyon velleyanum* rests solely on Decaisne's citation of Velley's description and illustration of the Australian plant (Trans. Linn. Soc. **5**: 169. *pl. 7*. 1800).

CAULERPA SERRULATA (Forssk.) J. Ag.

Caulerpa freycinetii Ag.

In 2–4 ft., Sta. 42.

[8] YAMADA, Y. Univ. Calif. Publ. Bot. **16**: 196. *fig. c* and *pl. 4. fig. a*. 1931.

HALIMEDA CUNEATA Hering.
In 2–4 ft., Sta. 42.
HALIMEDA OPUNTIA (L.) Lamour.
A rather small-segmented form, in 22 ft., Sta. 28.
CODIUM CORONATUM Setchell
In 10 ft., Sta. 68. Type from Tahiti.

PHAEOPHYCEAE

COLPOMENIA SINUOSA (Roth) Derb. & Sol., *forma.*
Attached to *Halimeda opuntia* in 22 ft., Sta. 28.
HYDROCLATHRUS CLATHRATUS (Bory) Howe
Hydroclathrus cancellatus Bory
In 2–4 ft., Sta. 42.
TURBINARIA ORNATA (Turn.) J. Ag.
In 2–4 ft., Sta. 42; in 5 ft., Sta. 41.
SARGASSUM PILULIFERUM (Turn.) Ag.
Floating, Sta. 84, Aug. 16; also, in 6 ft., Sta. 38.

Of the four plants collected at Station 38, one is copiously supplied with the air-vesicles from which the species derived its name, one shows only one vesicle, and the other two have none. The plants from Station 38 differ from the floating specimen of Station 84 in their lighter color, in their often more setaceous leaf-segments and more obscure midribs, and in the somewhat shorter pedicels of the vesicles. They seem to approach *Sargassum setaceum* Yendo,[9] the type of which, like that of *S. piluliferum,* is Japanese, but most of the leaf-segments are distinctly flattened and show an obvious costa. The vesicles in both the floating and attached forms have occasional cryptostomata, a character that Yendo denies to *S. piluliferum* and allows to the upper and median vesicles of his *S. setaceum.*
SARGASSUM VULGARE LINEARIFOLUM J. Ag. (?)
In 24 ft. of water on coral and sand [probably unattached], Sta. 60. The specimen agrees very well with Yendo's figure of this variety (op. cit. *pl. 17, f. 5*), as represented in Japan.

RHODOPHYCEAE

Laurencia galtsoffii sp. nov.[10]

Forming compact cushions 1–2 cm. high, branching irregular, for the most part subdichotomous or somewhat corymbose, the main divisions

[9] Journ. Coll. Sci. Imp. Univ. Tokyo. **21**[12]: 60. *pl. 7. figs. 5–7.* 1907.
[10] Frondibus caespites compactas 1–2 cm. altas formantibus, plerumque irregulariter ramosis, plerumque subdichotomis aut aliquando corymbosis, segmentis principalibus teretibus aut subteretibus, plerumque 0.45–0.78 mm. crassis; ramulis terminalibus teretibus truncati-obtusis, 0.4–0.62 mm. crassis, juvenilibus aliquando subturbinatis; cellulis superficialibus a superficie visis plus minusve hexagonis, in partibus veteribus oblongis, 35–110μ in diam. max., in sectione transversali suborbicularibus, circa

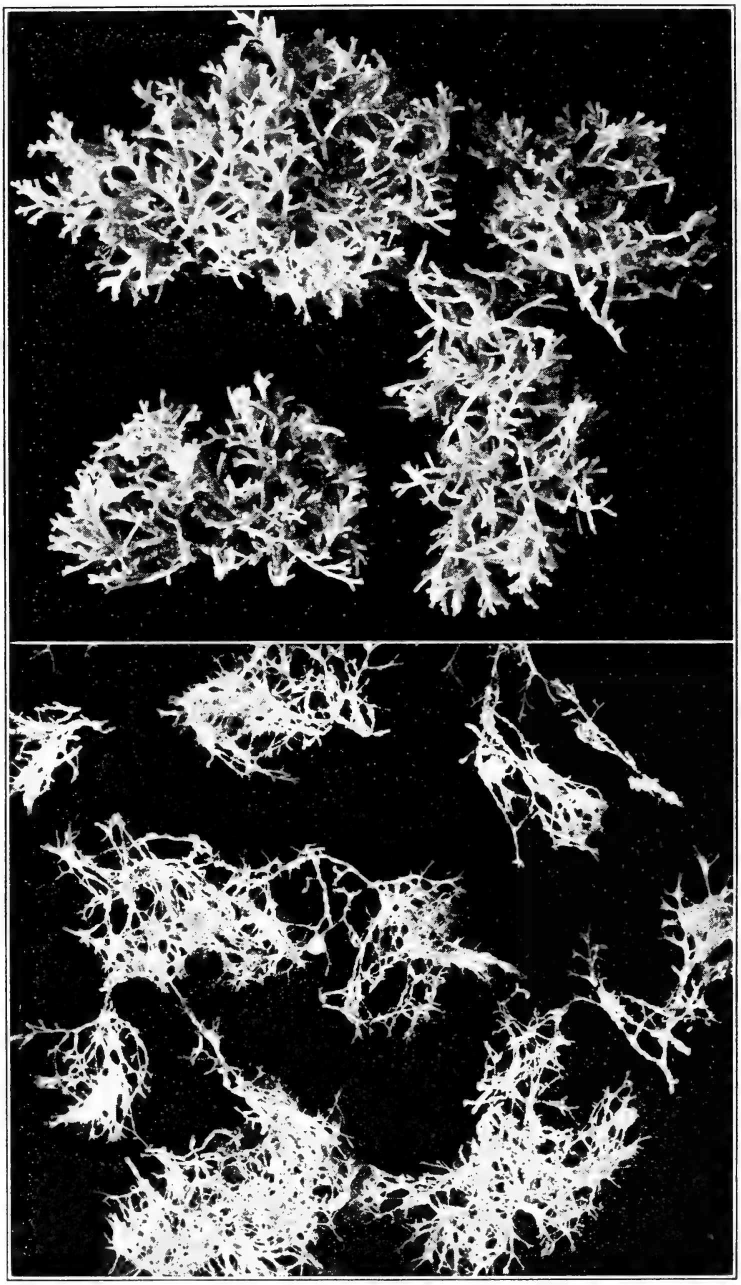

Fig. 5.—*Laurencia galtsoffii*. Type, top from fluid, lower same material dried. Natural size.

30–52μ altis, in partibus junioribus plerumque leviter mammiformi-prominentibus, parietibus 5–15μ crassis; cellularum medullarium parietibus incrassationibus lenticularibus aut annularibus saepe instructis; partes aliae desunt.

In profunditate 3 m. in loco "Pearl and Hermes Reef" dicto, Oceani Pacifici, Lat. 27°52′35″ Bor. Long. 175°47′ Occ., Paul C. Galtsoff legit. Species *L. pannosae* Zanard. forsitan affinis est.

terete or subterete, mostly 0.46 to 0.78 mm. in diameter; terminal branches cylindric and truncate-obtuse, 0.4–0.62 mm. in diameter, the younger occasionally subturbinate; surface cells more or less hexagonal, becoming oblong in older parts, 35–110μ in maximum diameter, cell walls 5–15μ thick, cells rounded and nearly isodiametric in transverse section, about 30–52μ high, usually lightly mammiform-protuberant in younger parts, walls of medullary cells often with lenticular, arcuate, or somewhat annulate thickenings; other parts wanting. [FIGURE 5.]

On sand and coral bottoms, in ten feet of water, temp. 26.4°C., Pearl and Hermes Reef, Station 68, Lat. 27° 52′ 35″ N., Long. 175° 47′ W., Paul C. Galtsoff, August 2, 1930. The original material, consisting of one clump of more than one plant, is divided between The New York Botanical Garden and the United States National Museum.

From *Laurencia pannosa* Zanard. of Sarawak, which we know only from original description and figures, *L. galtsoffii* would appear to differ in its cylindric rather than verrucaeform ultimate branches and in its more dichotomous-corymbose branching; from *L. nana* Howe of the Bahama Islands (this species also often has lenticular thickenings in the walls of its medullary cells), in its absence of rhizoidal haptera and its coarser segments (0.4–0.78 mm. *vs.* 0.1–0.45 mm.); from *L. pygmaea* Weber-van Bosse, of the Chagos Archipelago, in its more dichotomo-corymbose branching and coarser segments; from *L. humilis* Setchell & Gardner of Clarion Island, Revillagigedo Islands, in being much more slender and more freely branched, in its more polygonal surface cells, and in the usually manifest lenticular thickenings of the walls of the medullary cells; and from *L. corymbosa* J. Ag. of the Cape of Good Hope, in its much smaller size.

Some of the plants grow attached to another species of *Laurencia*, possibly a reduced multifarious form of the following *Laurencia* sp.

LAURENCIA sp.

Fronds 3–5 cm. high, rather distinctly compressed, subpinnate or here and there subbipinnate or irregularly branched from a percurrent axis, main axis 1–2 mm. broad; ultimate branchlets verrucaeform to cylindric-clavate; surface cells mostly hexagonal, 30–45μ in diameter, rather thin-walled, often broader than high in transverse section, those in apical regions usually mammiform-protuberant; walls of medullary cells apparently without lenticular thickenings; stichidia short.

In 23 feet of water, on coral sand, Station 31, July 23. Only five or six fronds were collected. Some of them are distinctly complanate and very nearly distichous; others show branching in various planes. The species may be allied to *Laurencia cartilaginea* Yamada from Japan and *L. tropica* Yamada from the Marianne Islands, but the plants are smaller and simpler than in either. A. A. Heller's no. from 2158 Oahu, distributed as *Laurencia pinnatifida*, probably represents the same species.

Goniolithon frutescens Fosl.

In 2–4 ft., Sta. 42.

Porolithon sp. and *Lithophyllum* sp. occur in small quantity (so far as shown by specimens obtained) in 5 ft. of water on a bottom of "broken corals," at Station 41. More abundant than either of these is a mysterious compact calcareous crust that shows on decalcification delicate intertangled short-celled filaments 1–2μ broad. No such slender filaments have been reported for the Lithothamnieae, so far as is known to the writer. No reproductive cells have been identified with certainty. Apparently the same thing occurs in the West Indies. (Compare Howe No. 4592, from Jamaica, which is a brilliant brick-red when living.)

BOTANY.—*New plants mainly from western South America.—IV.*[1]

Ellsworth P. Killip, U. S. National Museum.

Most of the species described in the present paper are based upon specimens which I have compared with type or authenticated material at the Royal Botanic Gardens, Kew, the British Museum (Natural History), the Museum d'Histoire Naturelle, Paris, the Botanisches Museum, Berlin, and the Jardin Botanico, Madrid. To the directors of these institutions I wish to express my appreciation of the many courtesies extended during the course of these studies.

Pilea ulei Killip, sp. nov.

Herba dioica glaberrima; stipulae minutae, triangulares, caducae; folia similia et subaequalia, ovata vel elliptico-ovata, apice caudato-acuminata, basi acuta vel subobtusa, serrata, dentibus apiculatis, triplinervia, nervis ad tertiam partem laminae attingentibus, cystolithis supra linearibus subtus punctiformibus; inflorescentia ♀ cymoso-paniculata, pedunculis et ramis tenerrimis, achaenis ovatis minutis laevibus.

Plant herbaceous, succulent, 35 cm. or more high, glabrous throughout; stipules minute, triangular, soon deciduous; petioles slender, 1 to 2.5 cm. long, the lowermost up to 5 cm. long; leaves of a node similar and subequal, ovate or elliptic-ovate, 5 to 10 cm. long, 1.5 to 3.5 cm. wide, caudate-acuminate at apex, acute or rarely subobtuse at base, serrate except at base (teeth strongly ascending, apiculate), triplinerved (nerves extending to upper third of blade), thin-membranous when dry, the cystoliths linear on upper surface, punctiform on lower surface; plants dioecious; pistillate inflorescence diffusely cymose-paniculate, up to 6 cm. long, the peduncle and the branches very slender, the perianth segments unequal, the largest barely 0.4 mm. long; achenes ovate, minute, 0.5 to 0.6 mm. long, smooth.

Type in the herbarium of the Muséum d'Histoire Naturelle, Paris, collected on moist rocks, Serra do Oratorio, State of Santa Catharina, Brazil, April, 1889, by E. Ule (no. 1194).

[1] Published by permission of the Secretary of the Smithsonian Institution. For preceding parts of this series see this Journal. **16**: 565–573. 1926; **19**: 191–195. 1929; **21**: 347–353. 1931. Received September 16, 1933.

This species apparently is most closely related to the Peruvian *P. citriodora*, differing in having caudate-acuminate, sharply serrate leaves (obtuse or short-acuminate and crenate-serrate in *P. citriodora*), bearing linear cystoliths on the upper surface and punctiform ones on the lower surface. The leaves are suggestive of *P. rhizobola*, of Brazil, but their cystoliths are very different.

Pouzolzia scaberrima Killip, sp. nov.

Ramuli subquadrangulares, dense villosuli; folia alternata, elliptico-lanceolata, apice attenuato-acuminata, concoloria, glabra, supra valde punctato-scabra, subtus laevia; flores in glomerulis axillaribus, sessilibus, androgyneis; calyx ♂ fere ad basim 4-lobatus; staminia 4; calyx ♀ bidentatus, puberulus, stigmate filiforme, caduco; achaenia lateovoidea, laevia.

Branchlets subquadrangular, densely villosulous; stipules narrowly lance-linear, 7 to 8 mm. long, about 1.5 mm. wide at base, subulate at apex, pale at margin, sparingly pilosulous without, glabrescent within; petioles subquadrangular, 1 to 2.5 cm. long, densely villosulous; leaves alternate, elliptic, lanceolate, 8 to 13 cm. long, 3 to 4 cm. wide, attenuate-acuminate at apex, rounded at base, symmetrical, entire, 3-nerved (lateral nerves extending to slightly above middle of blade), reticulate-veined (nerves and veins pale beneath), concolorous, glabrous, strongly punctate-scabrous above, smooth beneath; flowers in dense sessile androgynous axillary glomerules; staminate flowers about 1.5 mm. wide, 4-lobed nearly to base, the lobes triangular-acute, apiculate, puberulent, the stamens 4, the filaments about 0.8 mm. long, the anthers suborbicular; pistillate perianth obscurely striate, bidentate, puberulent; stigma filiform, soon deciduous; achenes broadly ovoid, about 1.2 mm. long, subacuminate, smooth, lustrous, light brown.

Type in the U. S. National Herbarium, no. 703,919, collected at Santa Marta, Department of Magdalena, Colombia, in 1898 or 1899, by H. H. Smith (no. 1436). Duplicates at Berlin, British Museum, Field Museum, Kew, and New York.

In the general shape of the leaves this species resembles *P. obliqua* and *P. petiolata*. Both of those plants have densely pubescent foliage, not at all scabrous. In *P. obliqua*, moreover, the leaves are nearly sessile and strongly oblique.

Phenax weddellianus Killip, sp. nov.

Planta suffrutescens, caule tenue subquadrangulato; folia parva, ovata vel ovato-lanceolata, acuta, trinervia, integerrima vel paucidentata, supra sparse strigillosa, subtus pilosula; flores in glomerulis parvis laxis, androgyneis vel rare unisexualibus; flores ♂ pedicellati, perigonio fere ad medium trilobato, lobis triangulato-ovatis, staminibus suborbiculatis; flores ♀ absque perianthio, bracteis 3 partim connatis achaenia terna includentibus; achaenia anguste ovoidea, acuminata, sparse villosula.

Plant suffrutescent, the stem slender, up to 3 mm. thick, subquadrangular, essentially glabrous; stipules lanceolate, about 1.5 mm. long and 0.6 mm. wide, deciduous; petioles 1 to 2 mm. long; leaves ovate or ovate-lanceolate, 5 to 18 mm. long, 3 to 8 mm. wide, acute at apex, subacute at base, entire or

with 1 or 2 coarse teeth on either side, 3-nerved, sparingly strigillose above, sparingly to densely pilosulous beneath; inflorescence axillary, loosely flowered, shorter than the petioles, the flower-clusters androgynous, rarely unisexual; staminate flowers pedicellate, the pedicels 1 to 1.2 mm. long, the perianth 2 mm. long, glabrous, 3-lobed nearly to middle, the lobes triangular-ovate, the stamens 3, suborbicular, about 0.8 mm. long; pistillate perianth none, the achenes in groups of 3, enclosed by 3, partially coalescent, finely villosulous dark bracts 1.5 to 2 mm. long; the stigma elongate-filiform; achenes narrowly ovoid, 1 mm. long, acuminate, dull, very sparingly pilosulous.

Type in the herbarium of the Muséum d'Histoire Naturelle, Paris, collected in the Department of Cuzco, Peru, October, 1839, to February, 1840, by Claude Gay.

Weddell has noted upon the label accompanying this curious specimen "Phenacis species anomala aut genus novum ille affine." It may well represent a genus distinct from *Phenax*, and if so, one that is undescribed. In all the species of *Phenax* with which I am acquainted the naked achenes are surrounded by free bracts which become more or less spreading and are not at all perianth-like. In this plant the bracts are partly united and enclose three achenes, their stigmas long-exserted, the unopened cluster giving the appearance of a perianth with three stigmas. In general habit, especially in the shape of the leaves and the loose flower clusters, the plant resembles *Phenax laxiflorus.*

Gaiadendron macranthum Killip, sp. nov.

Frutex ubique glaber; folia opposita, obovata, obtusa, basi cuneata, subtus dense punctata; inflorescentia racemosa, floribus ternis, lateralibus breviter pedicellatis, terminali sessili; calyx cylindricus limbo patente integro; petala 7 libra, anguste linearia; filamenta petala subaequantia.

Shrub about 2 meters high, glabrous throughout; branches subterete; leaves opposite, obovate, 3.5 to 5 cm. long, 1.5 to 2.3 cm. wide, obtuse at apex, cuneate at base, short (about 4 mm.)-petioled, 1-nerved (nerve impressed above), densely punctate beneath, coriaceous, lustrous; inflorescence racemose, 10 to 15 cm. long, the branches opposite, divaricate, squarrose; bracts similar in texture, shape, and punctation to the leaves, 2.5 to 0.8 cm. long, 1 to 0.4 cm. wide, persistent; flowers in three's, the lateral short-pediceled, the middle sessile, the bractlets ovate, 5 to 7 mm. long, 4 to 5 mm. wide, concave, persistent; calyx cylindric, about 4 mm. long, 2 mm. in diameter, the margin flaring, entire; petals 7, distinct to base, narrowly linear, 3 to 3.5 cm. long, about 1 mm. wide, acute, orange; filaments subequal to the petals, the anthers narrowly oblong, about 4 mm. long; style subequal to the filaments.

Type in the herbarium of the Field Museum of Natural History, no. 562,433, collected at Putis, Choimacota Valley, Province of Huanta, Department of Ayacucho, Peru, altitude 3,400 to 3,500 meters. February 27 to March 12, 1926, by A. Weberbauer (no. 7523).

This is one of the non-parasitic Loranthaceae, true trees or shrubs, which have been placed in various genera, but now are usually referred to *Gaiaden-*

dron. From *G. punctatum, G. tagua,* and *G. puracense* the proposed species differs in the large leaf-like bracts, larger bractlets, and longer petals.

Phrygilanthus linearis Killip, sp. nov.

Frutex parasiticus glaber; rami teretes; folia alterna vel subopposita, linearia, obtusa, sessilia, obscure 1-nervia; inflorescentia subcorymbosa, floribus ternis pedicellatis; bracteolae triangulari-ovatae, persistentes; cupula teres, denticulata; calyx quam cupula paullo longior, subinteger; petala anguste linearia, acuta.

Parasitic shrub, glabrous throughout; branches terete, grass-green, the internodes 2 to 3.5 cm. long; leaves alternate or subopposite, linear, 2 to 3.5 cm. long, 1.5 to 5 mm. wide, obtuse, sometimes minutely mucronulate at apex, slightly narrowed at base, sessile, obscurely 1-nerved, fleshy; inflorescence subcorymbose, compact, the flowers in three's, pedicellate, the peduncles and pedicels squarrose, the pedicels 3 to 5 mm. long; bractlets triangular-ovate, 2 to 3 mm. long, 1.5 to 2 mm. wide, concave, persistent; cupula cupuliform, 2 to 2.5 mm. long, terete, denticulate; calyx slightly longer than the cupula, subentire; petals 6, narrowly linear, 2 to 2.5 cm. long, 0.7 to 0.8 mm. wide, acute, bright red or scarlet; filaments very slender, about 2 cm. long; anthers linear-oblong, 3 mm. long; style subequal to or slightly longer than the petals; fruit ovoid.

Type in the U. S. National Herbarium, no. 1,281,718, collected at Talara, Province of Paita, Department of Piura, Peru, September 16, 1925, by Oscar Haught (no. 9). Represented also by Weberbauer's 7765, collected at La Brea, in the same province, and perhaps by Townsend's 823, the latter having leaves up to 6 cm. long and 1.5 cm. wide.

This species is nearest to *P. flagellaris* (Cham. & Schlecht.) Eichl., a plant ranging from southern Brazil to Argentina, which has a longer cupula, with more pronounced teeth, and deciduous bractlets. The proposed species does not appear to have the flagellate habit of *P. flagellaris.* The leaves are suggestive of *P. cuneifolius* (R. & P.) Eichl., but in that species the flowers are solitary. Weberbauer notes that the plant was parasitic on species of *Acacia.* Haught states, "*Piña,* a slender semi-trailing plant growing nearly always on *algarroba* [*Prosopis limensis*]. The branches reach a length of 6 to 8 feet. Flowers are produced throughout the year, and are bright red. The two species of Loranthaceae commonly found here [this and *Psittacanthus obovatus*] are not infested by insects to any extent, but goats seem to prefer them to any other plant. Goat-herders break *piña* off trees with long poles for their animals."

Phrygilanthus tumbecensis Killip, sp. nov.

Frutex parasiticus glaber; folia opposita, anguste oblonga, subfalcata, obtusa, sessilia; inflorescentia laxe corymbosa; bracteolae triangulari-ovatae, concavae; cupula patelliformis, remote denticulata; petala linearia, acuta.

Parasitic shrub, glabrous throughout; branches terete, drying dark brown; leaves opposite, narrowly oblong, subfalcate, 5 to 10 cm. long, 1.5 to 3 cm. wide, obtuse at apex, narrowed at base, sessile, 1-nerved with numerous obscure ascending secondary nerves, fleshy; inflorescence loosely corymbose,

the peduncles stout, squarrose, about 1.5 cm. long, the secondary branches opposite, stout, the flowers in three's; bractlets triangular-ovate, 2 to 3 mm. long, concave, fleshy, subpersistent, cupula patelliform, 2 to 2.5 mm. long, 4 to 5 mm. wide, remotely denticulate; calyx subcylindric, slightly exceeding the cupula, denticulate; petals 6, linear, 3 to 4 cm. long, about 1 mm. wide, acute, "fiery red with yellow point"; anthers linear, about 4 mm. long; style about 4 cm. long.

Type in the U. S. National Herbarium, no. 1,420,154, collected in mountains east of Hacienda Chicama, Province of Tumbez, Department of Tumbez, Peru, altitude 500 to 700 meters, February, 1927, by A. Weberbauer (no. 7668).

This is a much coarser plant than *P. linearis,* to which it appears to be most nearly allied. The leaves are opposite and much broader, and they have a very blunt apex. The inflorescence is few-flowered and the petals are larger.

All the specimens of Loranthaceae discussed in the present paper I have compared with material at the herbaria at Berlin.

Hesperomeles goudotiana (Dcne.) Killip

Osteomeles goudotiana Dcne. Nouv. Arch. Mus. Hist. Nat. **10:** 182. 1874.

Specimens examined: Colombia: Cundinamarca: Bogotá, *Mutis* 4328 (Madrid, U. S. N. M.), *Goudot* (type, Paris); *Triana* 4182 (Berlin, Paris, U. S. N. M.); *Perez* 1092 (U. S. N. M.).

I fully agree with Macbride, Schneider, and others that *Osteomeles* should be restricted to the Hawaiian and Chinese species.

Hesperomeles pachyphylla (Pittier) Killip.

Osteomeles pachyphylla Pittier, Contr. U. S. Nat. Herb. **20:** 109. 1918.

Specimens examined: Colombia: Páramo de Buena Vista, Huila Group, Central Cordillera, *Pittier* 1183 (U. S. N. M., type). Ecuador: Pichincha: Turubamba Valley, *Firmin* 298 (U. S. N. M.). Alangasi, *Firmin* 610 (U. S. N. M.).

Hesperomeles nitida Killip, sp. nov.

Frutex, ramis adultis cinereis, glabris, junioribus rufo-hirsuto-tomentosis; folia late ovata vel suborbiculata, apice rotundata, basi cordulata, crenata vel crenato-serrata, supra nitida, pilis nigrescentibus tenuiter hirsutula, subtus in costa dense rufo-hirsutula; inflorescentiae pauciflorae; fructus globosus, ruber, rufo-hirsuto-tomentosus, lobis calycis triangularibus acicularibus.

Compact shrub, 1 to 2 meters high, the older branchlets cinereous, glabrous, the younger rufo-hirsute-tomentose; leaves broadly ovate or suborbicular, 1.5 to 2.5 cm. long, 1.5 to 3 cm. wide, rounded at apex, cordulate at base, short-petioled (petioles up to 5 mm. long, rufo-hirsutulous), crenate or crenate-serrate, above lustrous and finely hirsutulous with blackish hairs, becoming glabrous, beneath densely rufo-hirsutulous on midnerve, less densely so elsewhere, the principal lateral nerves 12 to 14 to a side; corymbs few (up to 7)-flowered, the branches densely rufo-hirsute-tomentose, the common peduncle up to 8 mm. long at fruiting time; fruit

globose, 5 to 6 mm. in diameter, red, rufo-hirsute-tomentose, becoming glabrous except at top and bottom; calyx lobes triangular, 1.5 to 3 mm. long, 1.5 to 2 mm. wide, acuminate, acicular, rufo-hirsute-tomentose.

Type in the U. S. National Museum, no. 1,353,547, collected at edge of woods, near La Baja, Department of Santander, Eastern Cordillera of Colombia, altitude 3,500 meters, January 24, 1927, by E. P. Killip and A. C. Smith (no. 18063).

The nature of the indument on the foliage and fruit distinguishes this from *H. goudotiana* and *H. obtusifolia,* species which it resembles in the general shape of the leaves. The plant is known as "mortiña," and the fruit is said to be edible.

Rubus bogotensis eglandulosus Killip, subsp. nov.

Planta pilis flavescentibus eglandulosis dense et molliter hirsuto-tomentosa.

Type in the U. S. National Herbarium, no. 1,354,798, collected on the eastern slope of the Páramo de Santurbán, toward Mutiscua, Eastern Cordillera of Colombia, altitude 3,600 to 3,900 meters, February 20, 1927, by E. P. Killip and A. C. Smith (no. 19595).

Acaciella curassavica Britton & Killip, sp. nov.

Frutex glaber vel sparse strigosus; folia 10-14 cm. longa, pinnis 2–7-jugis, foliolis 6–21-jugis, obtusis, oblongis, ellipticis, vel supremis obovatis; capitula in paniculis laxis terminalibus, oblonga vel subglobosa; legumen oblongum, 5–8 cm. longum, 1.2–1.5 cm. latum, inter semina impressum, obtusum, basi late cuneatum; semina lenticularia, suborbicularia.

Shrub up to 2 meters high, glabrous, or the young twigs and leaf-rachis sparingly strigose; leaves 10 to 14 cm. long, the pinnae 2 to 7 pairs, the rachilla very slender, the leaflets 6 to 21 pairs, oblong or elliptic (or the upper pair obovate), membranous, dull, obtuse, or rounded, 4 to 9 mm. long, the midvein slender, the lateral venation delicate, or obscure; heads in loose terminal panicles, oblong or subglobose, in bud 4 to 6 mm. long; peduncles 1 to 1.5 cm. long, nearly filiform; pedicels about 0.4 mm. long; calyx about 1 mm. long, 5-toothed; corolla about 2 mm. long, 5-lobed; stamens many, distinct, about 5 mm. long; legume oblong, transversely forked-veined, obtuse, apiculate, impressed between the 5 to 8 seeds, 5 to 8 cm. long, 1.2 to 1.5 cm. wide, the base broadly cuneate, the stipe 6 to 10 mm. long; seeds lenticular, suborbicular, brown, faintly variegated, about 3 mm. in diameter, the raphe oblong.

Type in the herbarium of the New York Botanical Garden, collected on limestone rocks near Willemstad, Curaçao, March 20 to 27, 1913, by N. L. Britton and J. A. Shafer (no. 2943). Duplicate in U. S. National Herbarium.

Additional material examined, all from Curaçao: *Killip & Smith* 21039, 21055, 21063; *Boldingh* 5560; *Curran & Haman* 137, 251, 255; *Rose* 22014.

This species was recorded by Boldingh[2] as *Acacia villosa* (Sw.) Willd., a species endemic in Jamaica, and was thus referred to also by Urban, who noted, however, that it differed from the Jamaica plant in several details.

[2] Fl. Ned. W. Ind. 206.

Derris amazonica Killip

Lonchocarpus negrensis Benth. Journ. Linn. Soc. **4**: Suppl. 98, 1860. Not *Derris negrensis* Benth.

Specimens examined: Brazil: Amazonas: Rio Negro, *Spruce* 1671 (type, Kew). Along Rio Negro, above Manáos, *Killip & Smith* 30044. Manáos, *Killip & Smith* 30191. São Paulo de Olivença, *Ducke* 23400. Pará: Gurupá, *Ducke* 17201.

One of the specimens which Mr. Smith and I collected has mature fruits, the broad wings of which show that the species belongs to *Derris* rather than to *Lonchocarpus*. The legumes of the type specimen are not well developed.

Under The American Code of Nomenclature the name for this plant would be **Deguelia amazonica** (not *Deguelia negrensis* Taub.).

Tropaeolum longiflorum Killip, sp. nov.

Herba scandens, glaberrima; stipulae lineares, subpersistentes; folia peltata, fere ad medium septemlobata, lobis obovatis, apice latioribus, rotundatis, minute calloso-mucronulatis; pedunculi longissimi quam folia multo longiores; calcar cylindricum, conspicue nervosum, rectum vel subcurvatum; sepala oblonga; petala spathulata, subaequalia, subtruncata, subintegra, 2 superioribus coccineis, 3 inferioribus aurantiacis venis coccineis.

Scandent herb, glabrous throughout; stipules linear, about 3 mm. long, coriaceous, subpersistent; petioles 3 to 4.5 cm. long, cirrhose; leaves 2 to 3 cm. long, 2.5 to 4 cm. wide, 7-lobed nearly to middle (lobes obovate, up to 1 cm. wide, rounded and minutely callose, mucronulate), peltate (proportion above petiole to below petiole about 7:1), papillose beneath; peduncles elongate, much exceeding the leaves, 12 to 15 cm. long; flowers 4 to 5 cm. long; spur cylindric, 3.2 to 3.5 cm. long, about 3 mm. wide at throat, conspicuously nerved, the tip straight or very slightly curved; sepals oblong, 8 to 10 mm. long, 3 to 5 mm. wide, obtuse; petals similar and subequal, 1.3 to 1.5 cm. long, 6 to 9 mm. wide, subtruncate, subentire, the two upper scarlet, the three lower orange with scarlet veins, all with dark brown veins at base.

Type in the U. S. National Herbarium, no. 1,473,481, collected near Atac, Río Masameric Valley, Province of Jauja, Department of Junín, Peru, altitude 3,400–3,500 meters, April 25, 1913, by A. Weberbauer (no. 6641).

The leaves of this species are of the same general outline as those of *T. septemlobum* and *T. purpureum*, though the lobes are longer and are broadened at the apex. The flowers are much larger, however, the spur being fully a centimeter longer, and the upper and the lower sets of petals are more nearly uniform than in either of these relatives. In leaf shape as well as in the size and form of the flowers the proposed species resembles *T. bicolor*, a representative of the *Serrato-ciliata* group of species.

Tropaeolum purpureum Killip, sp. nov.

Herba scandens, glaberrima; stipulae lineari-subulatae, caducissimae; folia peltata, septemlobata, lobis rotundatis vel truncatis, mucronulatis, basi truncata, subtus glauca; flores 2–2.5 cm. longi; calcar cylindrico-conicum, basi subcurvatum, brunneo-rubrum, sparse purpureo-punctatum;

sepala oblonga; petala spathulato-unguiculata, sepalis longiora, apice crenulata, purpurea.

Scandent herb, glabrous throughout; stipules linear-subulate, 1 to 1.5 mm. long, soon deciduous; petioles 3 to 6 cm. long; leaves 2.5 to 4 cm. long, 3 to 4.5 cm. wide, 7-lobed (length of lobes:nerves::1:4), the lobes rounded or truncate, mucronulate), peltate (proportion above petiole to below petiole about 4:1), epapillose, glaucous beneath; flowers 2 to 2.5 cm. long; spur cylindric-conical, about 1.2 cm. long and 3.5 mm. wide at throat, slightly curved at tip, brownish red; sepals oblong, 8 to 9 mm. long, about 5 mm. wide, obtuse, brownish red; petals spatulate-unguiculate, crenulate at apex, purple, 5 to 6 mm. wide, the upper about 1 cm. long, the lower about 1.5 cm. long.

Type in the herbarium of the Field Herbarium of Natural History, no. 605,323, collected at Marcapata, Province of Quispicanchi, Department of Cuzco, Peru, altitude 3,200 meters, February 15, 16, 1929, by A. Weberbauer (no. 7788). Duplicate at Berlin.

This species comes nearest *T. crenatiflorum* Hook. f. and *T. septemlobum* Heilb.; differing from both in having purple, rather than yellow or yellowish red petals, a coloring found more usually in species of the *Serrato-ciliata* group. The flowers appear to be rather similar in shape to those of *T. crenatiflorum*, though they are much smaller. The leaves are 5-lobed in that species. From *T. septemlobum*, a species of central Ecuador with leaves of similar outline, *T. purpureum* differs further in the crenate petals.

Mabea acutissima Killip, sp. nov.

Arbor gracilis glaberrima, inflorescentia excepta; folia lineari-lanceolata, ad apicem subabrupte et acutissime caudata, basi subrotundata, minute venulosa, supra nitidula, subtus glaucescentia; paniculae ramuli ♂ glaberrimi, umbelliformes, 3-flores, pedicellis filiformibus, elongatis, bracteis linearibus, utrinque glandula nigra oblonga ornatis, sepalis late triangularibus, eglandulosis; sepalis ♀ ovato-lanceolatis, eglandulosis; stamina ca. 30.

Slender tree about 6 meters high, glabrous throughout; leaves linear-lanceolate, 5 to 8 cm. long, 1 to 1.2 cm. wide, subabruptly tapering to a long and very sharp point (this 1.5 to 2 cm. long, up to 2 mm. wide), subrotund at base, short-petioled (petiole filiform, about 2 mm. long), minutely serrulate, bright green and lustrous above, glaucescent beneath; panicle 7 to 9 cm. long, 2 to 3 cm. wide, deep red, the ♂ branches glabrous, biglandular at base, the glands oblong, up to 2 mm. long and 1 mm. wide, black, 3-flowered, the flowers pedicellate, the pedicels filiform, 1 to 1.3 cm. long, minutely puberulent, ovate, the bracts about 3 mm. long, flowers ♂ 2 to 3 mm. wide, deep red, the sepals broadly triangular, 0.5 mm. long, subobtuse, eglandular; sepals ♀ ovate-lanceolate, 2 to 2.5 mm. long, 1 mm. wide, acuminate, eglandular; ovary ovoid, puberulent; style 1.2 to 1.4 cm. long, puberulent; stamens about 30.

Type in the U. S. National Herbarium, no. 1,518,780, collected at Tutunendo, 80 kilometers north of Quibdó, Intendencia del Chocó, Colombia, altitude about 80 meters, May 19, 20, 1931, by W. A. Archer (no. 2133).

In the monograph of the genus in Das Pflanzenreich[3] this species keys out

[3] IV. **147**[5]: 25–42. 1912.

to the group of *Umbelluliferae*, species 16 to 19. From these four species it differs in having very narrow leaves, which more closely resemble those of *M. angustifolia* and *M. longifolia.*

Buettneria flexuosa Killip, sp. nov.

Frutex espinosus, ramulis juvenilibus flexuosis, crassis, subhexagonis, 6-costatis, ferrugineis, sparse vel dense hirsutulis; folia lanceolata vel ovato-lanceolata, acuminata, basi rotundata, denticulata, quinquenervia, utrinque ferrugineo-tomentosa; inflorescentia subpaniculata, pedicellis tenuibus, floribus parvis; calyx campanulatus, lobis lanceolatis; cucullus petalorum obcordatus, ligula filiformi, glabra.

Shrub 3 to 4 meters high, spineless, the branchlets obscurely 6-angled, 6-costate, ferruginous, sparsely to densely hirsutulous; petioles 1 to 3 cm. long, ferruginous-villous; leaves lanceolate or ovate-lanceolate, 6 to 9 cm. long, 2 to 5 cm. wide, acuminate at apex, rounded at base, denticulate, 5-nerved (nerves impressed above), densely ferruginous-tomentose; inflorescence axillary, subpaniculate, about 2 cm. long, the pedicels slender, 2 to 3 mm. long; calyx tube campanulate, about 1.5 mm. long, 3 mm. wide, the lobes lanceolate, 3 mm. long, 1.5 mm. wide, acute; petals about 1 mm. long exclusive of a filiform glabrous ligule 2 mm. long; stamen tube about 1 mm. long.

Type in the herbarium of the New York Botanical Garden, collected at Loja, Ecuador, November 12, 1876, by E. André (no. 4435). André's K870, from the same locality, and K879, from Chuquiribamba, Ecuador, both belong to this species.

In the general shape of the leaves and in the dense indument this species is suggestive of *B. mollis* H. B. K. and *B. hirsuta* R. & P., both of which are spine-bearing. In addition, *B. mollis* has deeply cordate leaves and a diffuse inflorescence.

Abatia macrostachya Killip, sp. nov.

Frutex ubique stellato-pubescens; folia ovata, apice acuta, basi auriculata, crenato-serrata; racemi terminales laxiflori, pedicellis tenuibus, 1.5–2 cm. longis, divaricatis, in fructu prope medium geniculatis; calycis segmenta anguste lanceolata, apice subulata, interne glabra; stamina fertilia ca. 35, sterilibus creberrimis; fructus subglobosus.

Shrub, the branchlets terete, finely floccose-tomentose with stellate yellowish-white hairs; leaves ovate, 10 to 18 cm. long, 6.5 to 10 cm. wide, acute at apex, auricular at base, crenate-serrate, membranous, sparingly stellate-hirtellous above, densely stellate-floccose on the principal nerves beneath, the petioles 2 to 3 cm. long, quadrangular; racemes terminal, loosely flowered, 20 to 25 cm. long, 5 to 6 cm. in diameter, the rachis subhexagonal, stellate-floccose, the pedicels slender, 1.5 to 2 cm. long, divaricate, at length geniculate near middle, the upper half ascending; calyx 4-parted nearly to base, the segments narrowly lanceolate, 7 to 8 mm. long, 2.5 to 3 mm. wide, attenuate to a subulate apex, flavo-stellate-tomentose without, glabrous within; petals none; fertile stamens about 35, the filaments filiform, about 5 mm. long, the anthers narrowly oblong, nearly 1.5 mm. long; sterile stamens very numerous (several hundred?), capillary, about 4 mm. long; ovary globose-conical, densely flavo-stellate-tomentose; style subulate, 7

to 8 mm. long, glabrous; fruit subglobose, 5 to 6 mm. in diameter, densely flavo-stellate-tomentose.

Type in the U. S. National Herbarium, no. 604,397, collected between Yanamechi and Amaibamba, Department of Cuzco, Peru, June 19, 1915, by O. F. Cook and G. B. Gilbert (no. 1136). Also represented by Herrera's 1568, from the Urubamba Valley, in the same department.

This is evidently a very handsome plant, with its long racemes of flowers. The pedicels of the individual flowers are much longer and more spreading than in the other species of this small genus.

Turnera ulmifolia serissima Killip, forma nov.

Caulis pilis brunneis adscendentibus dense vestitus; folia obovata, acuta, minute denticulata, dentibus mucronulatis, pilis albidis ubique densissime sericea.

Type in the U. S. National Herbarium, no. 1,351,104, collected on the Mesa de los Santos, Department of Santander, Eastern Cordillera of Colombia, altitude 1,500 meters, December 12, 1926, by E. P. Killip and A. C. Smith (no. 15179).

This plant is far more densely sericeous than any of the variants of the polymorphic species *T. ulmifolia.* The toothing of the leaves is much finer than in most of the variants.

Cajophora smithii Killip, sp. nov.

Planta scandens; caulis villosulus, sparse retrorso-setulosus; folia lanceolata, supra medium pinnatilobata, infra medium pinnatipartita (segmentis jugi infimi petiolulatis), supra scabrida, subtus minute villosula; ovarium subconicum, dense setosum; lobi calycis lineares; petala cymbiformia; squamae saccato-convexae, oblongae, apice incrassatae, bicornes, trinerves, prope medium dorsi appendices 3 oblanceolatas acutas albas gerentes; staminodia ad quamque squamam 2, falciformia, papillosa, apice filiformia; stamina ca. 80.

Herbaceous vine; stem sparsely and minutely villosulous, very sparingly setulose with minute retrorse hairs; petioles 2 to 3.5 cm. long; leaves lanceolate, 5 to 7 cm. long, 3.5 to 5 cm. wide, pinnately lobed in upper half, pinnatisect to rachis in lower half (lowermost pair of segments petiolulate, the segments ovate or lanceolate, dentate, the terminal segment denticulate), scabrid above with short appressed hairs, finely villosulous beneath; peduncles about 1 cm. long, very slender; ovary obconic, about 7 mm. long, 5 mm. wide at apex, densely setose; calyx lobes linear, about 1 cm. long, up to 1 mm. wide; petals cymbiform, 1 cm. long, 7 mm. wide, villosulous and sparingly and weakly setulose without, orange; scales green, saccate-convex, oblong, 4 mm. long, 1.5 mm. wide, strongly thickened at apex, 2-horned, 3-nerved, bearing dorsally near middle 3 oblanceolate acute white appendages about 2 mm. long, 0.8 mm. wide; staminodia 2 to a scale, falciform, about 5 mm. long, papillose, white, filiform at apex; stamens about 80, 5 to 6 mm. long, the anthers ovate.

Type in the U. S. National Herbarium, no. 1,358,846, collected at Carpapata, above Huacapistana, Department of Junín, Peru, altitude 3,000 meters, June 7, 1929, by E. P. Killip and A. C. Smith (no. 24419).

Apparently this species comes nearest to the Argentinan *C. clavata* in Urban and Gilg's monograph of Loasaceae, because of the general shape of the appendages of the scales. In *C. clavata* these are said to be filiform, narrowly laminuliform-dilated at the apex, thus differing from those of the proposed species. The leaves of that species, moreover, are ovate.

ZOOLOGY.—*A new sea-urchin from Florida.*[1] AUSTIN H. CLARK, U. S. National Museum.

While working at the Dry Tortugas laboratory of the Carnegie Institution of Washington Mr. P. Powers of the University of Pennsylvania obtained some specimens of a fine new species of *Astropyga* which he was so kind as to submit to me for study.

As at present understood, the genus *Astropyga* includes two species, *A. radiata,* ranging from Zanzibar to the Hawaiian Islands, which was beautifully figured by Seba as *Echionanthus major* in 1758 and described by Leske as *Cidaris radiata* in 1778, and *A. pulvinata,* occurring on the west coast of Mexico and Central America, which was described by Lamarck under the name of *Cidarites pulvinata* in 1816. The discovery of a third species of this interesting genus of large and conspicuous littoral sea-urchins in Florida waters at this late date is therefore a matter of no little interest, and this interest is increased by the fact that, with the sole exception of *Tripneustes esculentus* which sometimes slightly exceeds it, this new species is the largest of the regular echinoids in the shallow waters of the tropical Atlantic.

The new species from Florida may be called

Astropyga magnifica, sp. nov.

Locality.—South of Dry Tortugas, Florida; 48 fathoms (88 meters); collected by Mr. P. Powers.

Diagnosis.—Related to *A. pulvinata* but with the ambitus circular instead of rounded pentagonal; with longer spines, which reach slightly more than half the diameter of the test in length; with a smaller peristome; and with only the outermost column of tubercles in each interambulacral area failing to reach the peristome. The color is uniform purplish black throughout.

The test is 145 mm. in diameter and 52 mm. high, thin and flexible, the plates interiorly with abrupt deep circular or oval pits corresponding to the primary tubercles, these pits becoming very numerous on the actinal surface. The oculogenital ring and the bare forked lines extending outward from the genital plates are deeply sunken so that the inner two-thirds of the ambulacral areas on the abactinal surface are much swollen. The whole animal is covered with rather thick soft skin.

The longest primary spines are about 75 mm. long; it is impossible to

[1] Published with the permission of the Secretary of the Smithsonian Institution. Received September 13, 1933.

estimate their length exactly as all of them are broken off at some distance from the tip. The interior of the spines is filled with a rather dense calcareous network so that they appear solid. The spines increase in diameter slightly and very slowly from the base for a distance of about 20 mm., then remain uniform for some distance, finally tapering gradually to the tip. In section they are circular at the base, becoming transversely oval outward and often considerably flattened distally. At the base they bear 20–24 sharply rounded ridges which a little way above the base break up into rows of elongated scales with overlapping distal ends. Distally these scales gradually become more and more oblique, finally making an angle of about 30° with the axis of the spine. They show a marked tendency to become arranged in irregular verticils.

In the interambulacral areas on the actinal surface the outermost column of tubercles ends abruptly about one-third of the distance from the ambitus to the peristome, but the next column curves inward and reaches the peristome. There are 12 columns of tubercles in each interambulacral area at the ambitus.

The diameter of the actinal system from the apex of one genital to the outer border of the opposite ocular is 28 mm. The diameter of the periproct, within the ring of encircling plates, is 11 mm.

The diameter of the peristomal area is 42 mm.

Type specimen.—Cat. No. E.3125, U. S. National Museum. A second large specimen is entered under No. E.3126, and two small ones under Nos. E.3127 and E.3128.

Notes.—Two young individuals 58 mm. in diameter and 18 mm. high and 49 mm. in diameter and 16 mm. high, resemble *A. pulvinata* more closely than do the adults. Their form is pentagonal with broadly rounded angles. The color (in formalin) is light reddish buff actinally becoming brighter pinkish in the interradial areas abactinally. Abactinally the bare central portion and the bare lines radiating from it are deep purple, this color being continued outward along the sides of the ambulacral areas as a progressively narrowing margin as far as the amitus, and further as a much lighter pinkish line to the peristome. Along this band bordering the ambulacral areas is a series of conspicuous brilliant blue spots, one to each plate. The spines are very light dull greenish with several narrow bands of bright pinkish-purple or sometimes more or less deep purple. Abactinally the ambulacral areas within the dark border are duller and less pinkish than the interambulacral areas. The ambulacral pores are arranged in a single irregular column. There are six columns of primary tubercles in each interambulacral area at the ambitus.

Remarks.—This species is very readily distinguished from all the other sea-urchins of the tropical Atlantic. In its general appearance and blackish color it suggests *Centrechinus* (or *Diadema*) *antillarum;* but it is at once differentiated from this species by its much shorter and more slender solid spines and its thin and flexible test, the inner side of which is deeply pitted. The young are very easily recognized by their conspicuous color pattern and by their form.

This species should be compared with *A. radiata,* but no comparable specimens of that form are available.

ZOOLOGY.—*Two new parasitic worms of* Didelphys aurita: Skrjabinofilaria pricei *n. sp. and* Gongylonema marsupialis *n. sp.*[1]
ZEFERINO VAZ and CLEMENTE PEREIR, Instituto Biologico, Sao Paulo, Brasil. (Communicated by BENJAMIN SCHWARTZ.)

Dr. Flavio da Fonseca of the Instituto Butantan, S. Paulo, has kindly sent us for study three lots of nematodes collected during post-mortem examination of *Didelphys aurita*. One of the lots contained some specimens of a Metastrongylidae, *Heterostrongylus heterostrongylus* Travassos,[2] 1925, taken from the lungs. The contents of the second lot were taken from the subcutaneous tissue and proved to be a new filarid worm. The third contained a few specimens of a *Gongylonema* which appear to us to be a new species.

Skrjabinofilaria pricei n. sp.

Fig. 1.

This new species can be included in the genus *Skrjabinofilaria* erected by Travassos, 1925, for a filarid worm parasitic in the subcutaneous tissue of the opossum. *S. pricei* is distinguished from *S. skrjabini* by the following characters: (1) shape of the anterior extremity, (2) absence of buccal capsule, (3) position of the vulva, (4) trifid tip of the tail in *S. pricei,* (5) absence of caudal alae, (6) number of caudal papillae.

Length: male 27–30 mm., female, 45–70 mm.

Thickness: male 0.14 mm., female, 0.2 mm.

Anterior extremity somewhat enlarged. Cuticle thin and smooth; lateral flanges absent. Mouth simple without lips, but surrounded by a small chitinous peribuccal ring; buccal capsule absent. Near the tip of the tail in each sex there is laterally a pair of small cuticular appendages giving the end of the tail a trifid appearance. Oesophagus divided in two portions: the anterior one measuring 0.36–0.5 mm. in length, and the posterior 0.7–1.01 mm.; sometimes there is no very clear line of demarcation between the two parts.

Male.—Posterior extremity spirally rolled with four pairs of preanal papillae and two pairs of postanal near the anus. Caudal alae absent. The anus is situated about 0.13 mm. from the trifid posterior extremity. Spicules unequal, the larger one measuring 0.16–0.18 mm. and the smaller 0.13–0.14 mm.

Female.—Opistodelphys; ovoviviparous. The vulva is 0.9–1.4 mm. behind the anterior end. The vagina is 0.6 mm. long and directed backward. The anus is situated 0.4 mm. from the posterior end.

Host.—*Didelphys aurita* Wied.

Location.—Subcutaneous tissue.

Geographic distribution.—S. Paulo, Brazil.

Types and cotypes.—Helminthological collection of the Instituto Biologico de S. Paulo, No. 1490. *Paratypes.* U. S. N. Museum helminthological collection No. 32533.

[1] Received September 14, 1933.

[2] Comp. Rend. Soc. Biol. Paris. **93**: 1255. 1925.

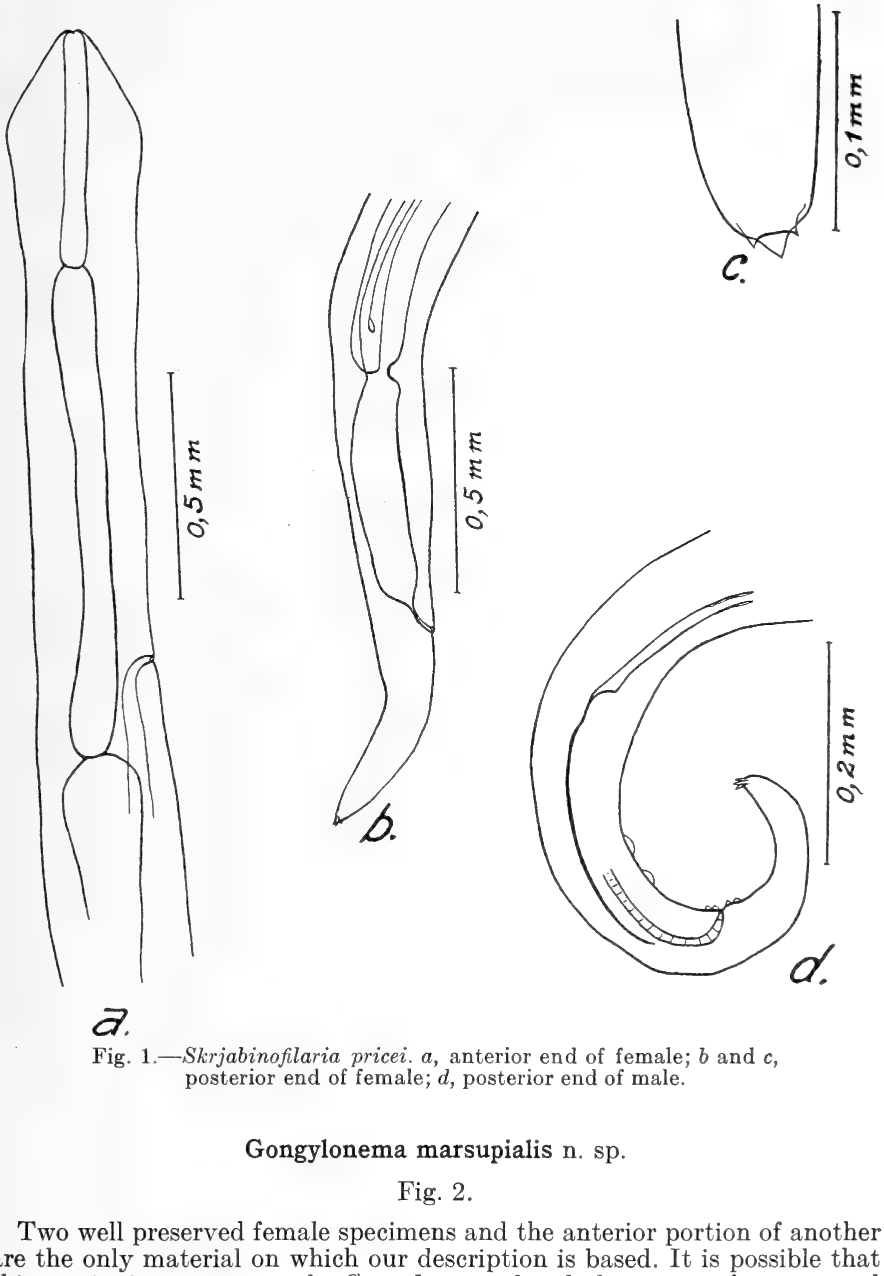

Fig. 1.—*Skrjabinofilaria pricei*. *a*, anterior end of female; *b* and *c*, posterior end of female; *d*, posterior end of male.

Gongylonema marsupialis n. sp.

Fig. 2.

Two well preserved female specimens and the anterior portion of another are the only material on which our description is based. It is possible that this species is a synonym of a *Gongylonema* already known; we have created it based on differences in the host and the geographic distribution. Only when male specimens have been studied can we say whether this new species is valid or not.

Female.—Length 37 mm. Thickness 0.26 mm. Mouth surrounded by

small dorsal and ventral lips. Cuticle thick, with transverse striations, bearing in the oesophageal region of the body a number of rounded or oval cuticular plaques arranged in three longitudinal rows on the dorsal and ventral parts. Cervical alae symmetrical and relatively broad, extending anteriorly to within 0.31 mm. of the extremity.

The pharynx is very short, measuring 0.049 mm. in length. The muscular portion of the oesophagus measures 0.74–0.8 mm. in length by 0.04 mm. in breadth. We cannot distinguish the posterior glandular portion of this organ. Nervous ring 0.52 mm. from the anterior extremity.

The vulva is situated towards the posterior extremity, 4.2 mm. from the tip of the tail. The short muscular ovejector is directed anteriorly. The uterus is entirely full of numerous little eggs; coils of uterine complex extending near the anus. The anus is situated 0.22–0.24 mm. from the very blunt posterior extremity.

Host.—*Didelphys aurita* Wied.

Location.—Mucous membrane of the oesophagus.

Geographic distribution.—S. Paulo, Brazil.

Allotypes.—Instituto Biologico de S. Paulo helminthological collection No. 1220.

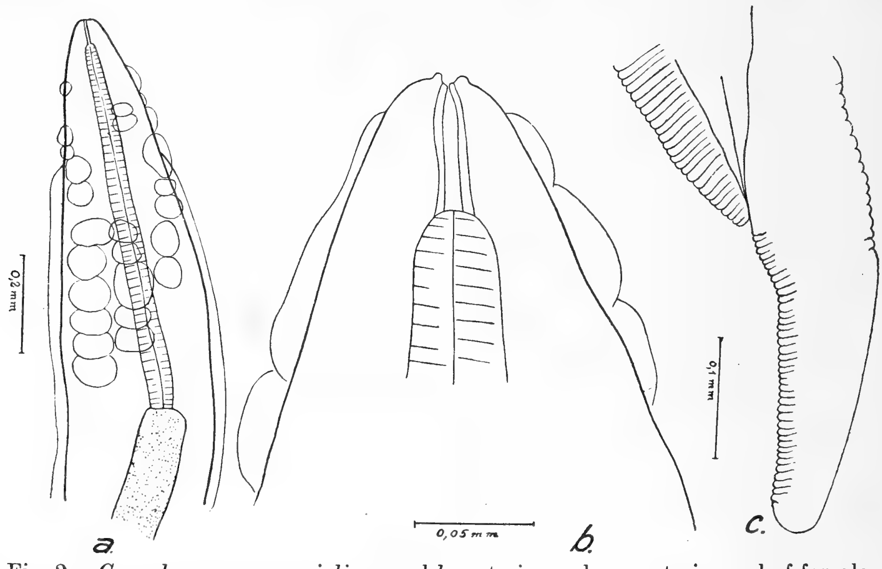

Fig. 2.—*Gongylonema marsupialis*. *a* and *b*, anterior end; *c*, posterior end of female.

ZOOLOGY.—*An annotation on the nematode genus* Pontonema *Leidy 1855*.[1] N. A. Cobb and G. Steiner, Bureau of Plant Industry.

Joseph Leidy described in 1855 and again in 1856 a new genus of free-living nematodes which he called *Pontonema*, and to which he re-

[1] The figures for this paper were prepared by Josephine F. Danforth and Florence M. Albin, and technical assistance was given by Edna M. Buhrer, all of the Division of Nematology, Bureau of Plant Industry. Received October 21, 1933.

ferred two species, *P. vacillatum* and *P. marinum*. Unfortunately Leidy's incomplete characterization of the genus and the two species did not allow later observers to recognize or place them properly. In 1927 a revision of the nematodes still available in Leidy's various collections was published by Walton. In this revision *Pontonema vacillatum* was referred to the genus *Oncholaimus* Dujardin and the species redescribed; *P. marinum* was transferred to *Enoplus*. About that same time, the senior author, in connection with investigations on nematodes from the New England coast, found it desirable to determine, if possible, the exact standing of the two forms.

From the redescription by Walton (4) it may well be seen that *Pontonema vacillatum* belongs to the Oncholaims but its membership in the genus *Oncholaimus* proper seems doubtful. As to *Enoplus marinus* as redescribed by Walton a more detailed characterization also seemed necessary to properly differentiate the form from other species. Such a revision was made possible through the courtesy of Dr. J. Percy Moore of the University of Pennsylvania, to whom we express our thanks.

THE GENUS PONTONEMA LEIDY 1855 (=PARONCHOLAIMUS FILIPJEV 1916)

Reexamination of the type material collected by Leidy proved that *Pontonema vacillatum* belongs to the genus *Paroncholaimus* Filipjev 1916. The latter genus is therefore a synonym of *Pontonema* which is now reestablished and *diagnosed* as follows:

Oncholaiminae with an anterior circle of six papillae and a posterior circle of ten short setae on the head, with three teeth in the buccal cavity, the two subventral ones of symmetrical position, equal size, and both larger than the dorsal one. Buccal cavity of strict dorso-ventral symmetry. Tail short, obtuse, curved. Female apparatus amphidelphic. Gubernaculum well developed.

Type: *Pontonema vacillatum* Leidy 1855.[2]

REDESCRIPTION OF PONTONEMA VACILLATUM LEIDY 1855

The body tapers slightly toward the head end; the tail of both sexes is short and obtuse, (fig. 1c, e, f) somewhat digitate in the male. The smooth, transparent cuticle is 6–7μ thick. There are six flap-like lips, each with a papilla at its base (fig. 1a). In addition there are ten short cephalic setae, of which one occurs in each lateral and two in each submedial sector. Short somatic setae also occur in longitudinal series in the oesophageal region of the body. The inconspicuous amphids are situated opposite the point of the dorsal tooth.

The buccal cavity is of typical shape, about 38–43μ wide and 75–85μ long, and the three teeth are placed as shown in fig. 1d. As in related forms the

[2] *Paroncholaimus vulgaris* (Bastian 1865) was declared type of the genus by Filipjev in 1916.

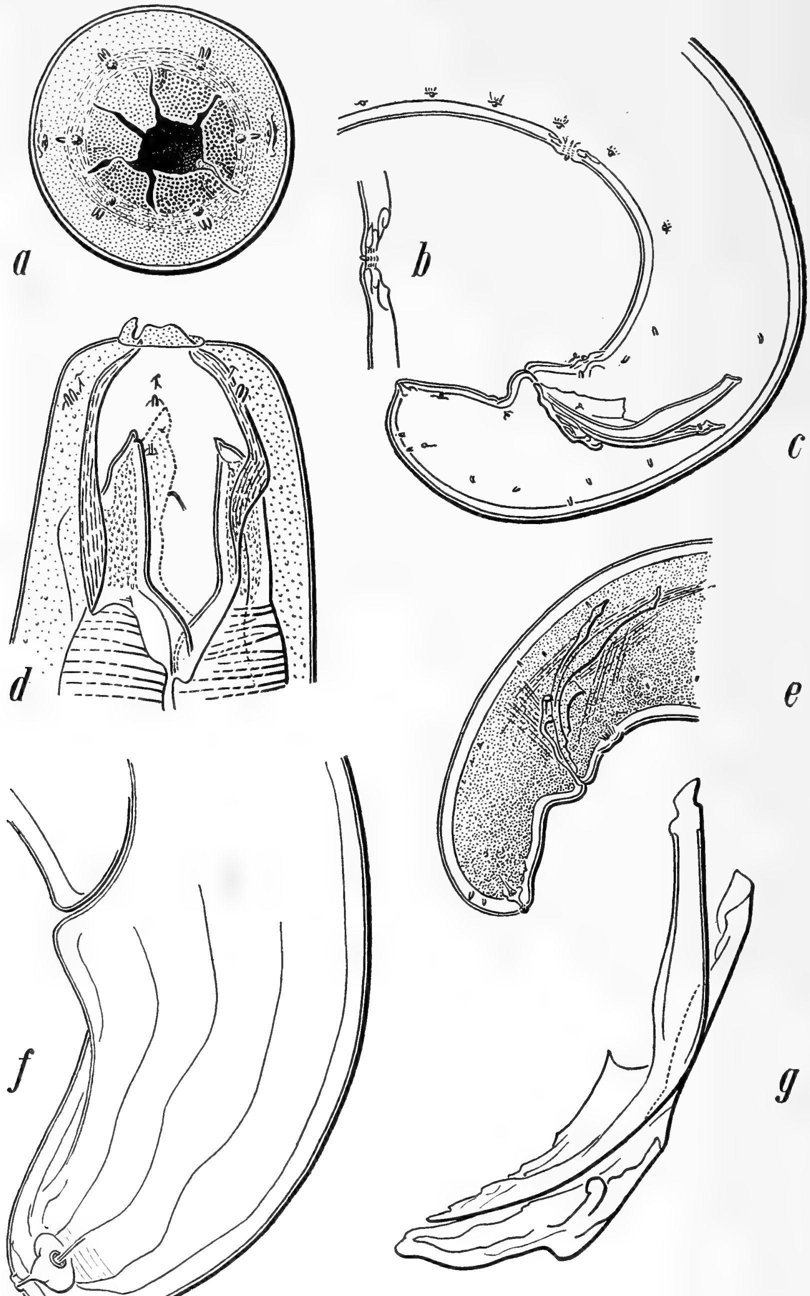

Fig. 1.—*Pontonema vacillatum* Leidy 1855 *a.*—Top view of head. ×515. *b.*—Detail of male ventro-median supplement, *c.*—Tail of male. ×235. *d.*—Lateral view of head of female. ×515. *e.*—Tail of male. ×235. *f.*—Tail of female showing spinneret. ×515. *g.*—Detail of spicula and gubernaculum.

oesophagus is of cylindrical shape, increasing somewhat posteriad in diameter. It is surrounded by the nerve-ring at about 0.5–0.6 mm. from the anterior end. The position of the caudal glands was not made out, but is undoubtedly preanal, as in other members of the group; their outlet, the spinneret, is very minute (fig. 1e, f).

The excretory pore opens about four and one-half times the length of the buccal cavity behind the head end.

The female apparatus is amphidelphic, with a larger posterior branch. This inequality in the size of the two branches is especially noticeable by the number of smooth, thin shelled eggs in the two uteri, the anterior containing up to eleven, the posterior up to twenty-four. These eggs are oval, measure $45\times55\mu$ and are apparently deposited unsegmented. The ovaries are reflexed.

In the male, the spicula are quite slender and of much simpler form than the gubernaculum, which, as shown in fig. 1g, is of complicated structure and almost as long as the spicula themselves. A pair of large preanal papillae is located a short distance anteriad of the anus, and farther forward, at about twice the spicula length in front of the anus, a ventromedian supplement is present (fig. 1c and fig. 1b). A number of papillate structures is furthermore spread over the male tail and also as a preanal ventrosubmedial series (fig. 1c).

$$♀\ \frac{.57 \quad ? \quad 7.7 \quad {}^{20\prime}51.{}^{\prime 27} \quad 99.2}{.54 \quad ? \quad .83 \quad .98 \quad .59}\ 16.3 \text{ mm.}$$

$$♂\ \frac{.47 \quad ? \quad 8.5 \quad \text{M} \quad 99.2}{.43 \quad ? \quad .94 \quad 1.3 \quad .77}\ 15.25 \text{ mm.}$$

Habitat.—Kennebunk Port, Maine.

Diagnosis.—*Pontonema* with the tail slightly longer than the anal body diameter with very short cephalic setae, with amphids opposite the point of the dorsal tooth, with the excretory pore at about four and one-half times the length of the buccal cavity behind the anterior end, with a longer posterior branch of the amphidelphic female apparatus; with gubernacula only slightly smaller in size than the spicula and also in the male with a pair of slightly submedial papillae in front of the anus.

REDESCRIPTION OF ENOPLUS MARINUS (LEIDY 1855) WALTON 1927

The cuticle is thin, measuring on the head only 5.5μ, in the oesophageal region 8μ. It is traversed by fine transverse striae. The head is set off by a fine line, a suture, as in other Enoplids, about two-thirds head-width back. There are ten cephalic setae—one in each lateral and two in each submedial sector. The latter are of unequal size, the longer one measuring about 22μ, its companion being about one-third shorter. A few short, small setae are scattered in the oesophageal region and on the tail. Around the oral opening six lips are seen, obscurely grouped in pairs. Each of the lips bears a mammiform papilla. In the buccal cavity the three equal, yellowish, slightly arcuate mandibles of 35μ length have their normal position, one dorsal and one in each ventro-submedial sector. Each mandible, 35μ long, has two slightly retrorse, distinctly separated prongs. Anteriorly each mandible is about 16μ

wide but tapers posteriorly rather regularly to its blunt end which is exactly opposite the aforementioned encircling suture. The lip region is supported by a refractive transverse triangular framework, serving for the attachment of the powerful buccal muscles. The small amphids occur a short distance behind the lateral setae; their ellipsoidal, transverse openings are about 12μ long. Their opening leads into a pouch-like structure behind which follows a fusiform cavity containing the sensilla.

As in other Enopli the three oesophageal glands empty near the base of the mandibles into the alimentary tract. No ocelli or pigment spots were seen on the oesophagus, but long preservation of the material may have caused their disappearance.

Behind the buccal cavity the oesophagus is about three-fifths, at the nerve-ring about one-half and at the base again three-fifths as wide as the corresponding portion of the body. The lateral chords opposite the middle of the oesophagus are about one-third as wide as the body, whereas in the middle of the nematode they seem to be more nearly half the corresponding body width. The number of cells making up the intestine in a cross section is estimated to be about 20; a few scattered intestinal cells are considerably larger than the rest. The rectum is about as long as the anal body diameter. The base of the tail tapers conically and thence onward it may be said to be subcylindroid in the posterior two-fifths, although the terminus is slightly

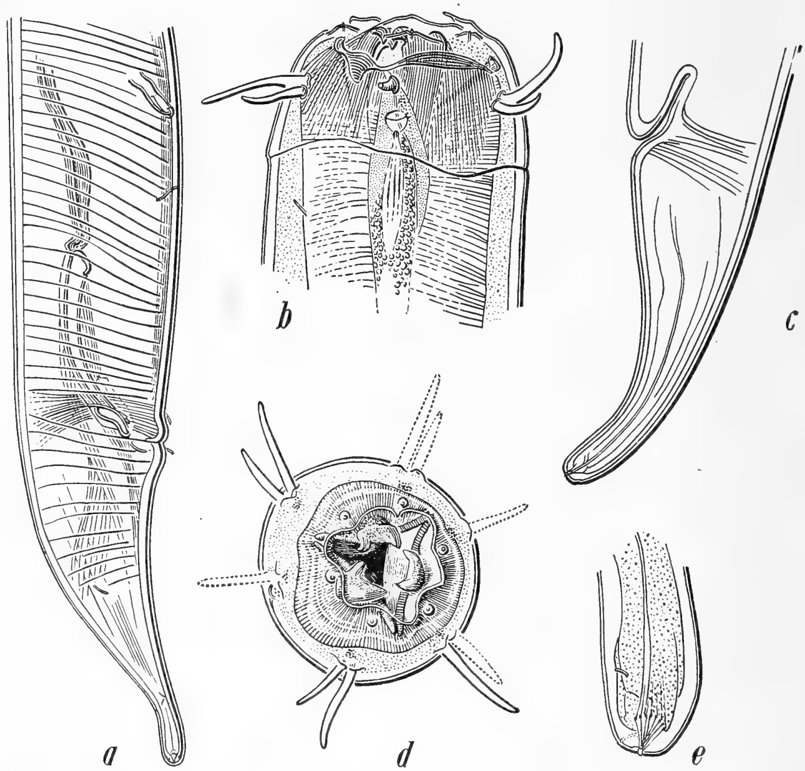

Fig. 2.—*Enoplus marinus* (Leidy 1855) Walton 1927 *a.*—Tail of male. ×170. *b.*—Lateral view of head of male. ×490. *c.*—Tail of female. ×170. *d.*—Top view of head of male. ×380. *e.*—Detail of tail showing spinneret. ×490.

swollen. A spinneret forms the opening of the large tubular outlets of the caudal glands.

The inconspicuous excretory pore is located halfway back to the nerve-ring. Vulva slightly raised, vagina leading in at right angles; female apparatus amphidelphic, ovaries reflexed. Three to four eggs, each about as long as the body is wide and two-thirds as wide as long, are contained in each uterus. The egg shell (1–2μ thick) seems to be smooth.

The male has two equal, rather flatly arcuate spicula, about two-thirds as long as the tail; they taper throughout their length. A double gubernaculum is about one-fourth as long as the spicula and a telamon slightly longer. The single tubular supplement ($65 \times 15\mu$) is located about twice the length of the spicula in front of the anus. Its length is about one-third the corresponding body width and it forms an angle of about 45° with the body axis. About one hundred posteriorly continuous oblique copulatory muscles (about 12μ wide) occur for a distance in front of the anus equal to 2–3 times the length of the tail. A few are located behind the anus.

$$\text{♀}\ \frac{0.3 \qquad 4. \qquad 10. \qquad {}^{18\prime}53.{}^{\prime 18} \qquad 96.6}{1. \qquad 1.5 \qquad 1.6 \qquad 1.9 \qquad 1.3}\ 8.8\text{ mm.}$$

$$\text{♂}\ \frac{0.4 \qquad 5. \qquad 12. \qquad \text{M} \qquad 97.1}{0.9 \qquad 1.4 \qquad 1.4 \qquad 2.2 \qquad 1.4}\ 8.33\text{ mm.}$$

Habitat.—Kennebunk Port, Maine, and in oyster bed, Atlantic City, New Jersey.

Diagnosis.—*Enoplus* resembling *E. brevis* Bastian, 1865, but differing from it by larger size (8–9 mm. instead of 4.–5.5 mm. in *E. brevis*), by a slightly shorter tail in the female, by regularly tapering spicula and by a more slender and smaller preanal supplement in the male.

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ZOOLOGY.—*Notes on certain pycnogonids including descriptions of two new species of* Pycnogonum.[1] Waldo L. Schmitt, U. S. National Museum.

Along with various collections of invertebrates received at the National Museum, there are a number of pycnogonids which seem worthy of record. Included are two apparently new species of *Pycno-*

[1] Published by permission of the Secretary of the Smithsonian Institution. Received November 3, 1933.

gonum, *P. rickettsi* and *P. hancocki*. The first of these new species comes from Pacific Grove, Monterey Bay, California, where it was collected by the donor, Mr. E. F. Ricketts, owner and director of the Pacific Biological Laboratories. The second was taken in the Galapagos Islands in the course of the recent survey of that zoologically unique group of islands by Captain G. Allan Hancock, of Los Angeles and Santa Maria, California, sponsor and leader of the Hancock Galapagos Expedition of 1933. This second new species is here published in advance of the more complete account of the results of the expedition in order to make this interesting find known without delay.

Pycnogonum rickettsi, new species

So far as I am aware, this is the first reticulated *Pycnogonum* found in the northern hemisphere. The proboscis is nearly as long as the first three trunk segments taken together, and is about half as wide as long.

Measured across the crurigers the first trunk segment is almost twice as wide as long in the median line; the width across the crurigers of the third segment is equal to the length of the first two segments, the width of the second segment is intermediate between the first and third. The first segment is about as long as the second and half the third taken together; the third is less than half the first in length and from two-thirds to three-fourths the length of the second.

The abdomen is a little longer than the fourth segment and the fused portion of the crurigers forming part of it taken together; it extends posteriorly as far as the first coxae of the last, fourth, pair of legs and its width is approximately equal to half its length.

The oculiferous tubercle arises a little behind the anterior margin of the segment; it is cylindrical, more or less rounded above, with the suggestion of a small "granular" tip or apex, and carries no accessory spines or tubercles either before or behind; the eye spots are faintly marked, of just slightly deeper and darker color than the body, and not at all as conspicuous as in the drawing. On the "neck" of the first segment in line behind the oculiferous tubercle is a stout conical, somewhat apically pointed spine, which is perhaps half again as high as the oculiferous tubercle; similar but stronger spines top the second and third segments, that on the second is the largest of the three. The third is intermediate in size between the first and second; the dorsum of the small triangular portion of the fourth segment proper is but slightly convexly raised medially, forming in some specimens more than in others a low, blunt, rounded and rather inconspicuous eminence.

The lateral processes of the body or crurigers are subequal to the first coxae in length, except that the first pair are a little longer than the corresponding coxae and the last pair, which bulk less than half, or only a third the size of the subjoined coxae. Each cruriger is armed at the middle of its upper distal margin with a well formed small spine or conical tubercle; these spines or tubercles decrease in size and height from last to first; the first are very small yet distinct and noticeable, the last pair are stouter and less spine-like; the others are intermediate in size and form. Similar stouter and larger tubercles are located on the distal margin of the first coxae of corresponding ambulatory legs; those on the first coxae of the last or fourth legs, are each

somewhat curved backward and outward; those on the first coxae of the third legs are less curved than those on the fourth pair and like the spines or tubercles topping the crurigers, they also decrease in size and prominence back to front; but individually each pair is slightly larger and stouter than the corresponding spines on the crurigers.

The second and third coxae of the ambulatory legs are without any particular armature; they are swollen or expanded distally, the first coxae of each leg appear somewhat nodulose, in dorsal view at least. All of the joints of the walking legs are roughened, more or less tubercular-granulate on the upper or outer surface; above, the distal margin of the femoral and first tibial joints are armed each with a pair of juxtaposed, stout, conical, lumpy, tubercles, the tibial pair of which is smaller than the femoral; similarly placed on the second tibial joint is an inconspicuous pair of small tubercles or nodules; between each of these several pairs of tubercles or nodules on the femoral and tibial joints arises a stout seta or hair.

In length the second tarsal joint of the third right leg about equals the second tibial joint and the first tarsal taken together; the terminal claw is about half, more or less, the length of the second tarsal joint; beneath, the first and second tarsal joints have a fairly dense fringe or multiple row of short spinules; similar spinules fewer in number and less definitely in rows occur on the under side of the second tibial joint; and some few scattered spinules are to be found here and there on the lower surface of the first tibial joint, and even more sparingly on the femoral joint.

Type and distribution.—One of two male specimens taken "from an anemone, probably *Metridium*, brought in by a 'dragboat' from deep water (60 fms.), Pacific Grove, March 31, 1925," by Mr. Ricketts has been selected as the holotype. It is slightly the larger of the two, and measures approximately: proboscis, length 3 mm.; greatest width, 1.2 mm; length of trunk to base of posterior crurigers, 3 mm.; abdomen 0.9 mm. long. The largest specimen of this species at hand is a female, which is but very little larger than the type. It has the proboscis 3.5 mm. long by 1.5 mm. wide; and trunk 4, and abdomen about 1.1 mm. long (measurements approximate). Regarding it, Mr. Ricketts says, "The large female was taken June 24, 1925, in 40–50 fms., mud bottom, off Pt. Davenport, about 14 miles N.W. of Santa Cruz on an anemone or Polynices shell.

"It is interesting to note that *Pycnogonum stearnsi* occurs almost invariably on *Metridium* on wharf piling, on barnacles that also have *Metridium*, or on *Bunodactis* in the tide pools; whereas the other larger [new] species of *Pycnogonum* seems to occur also in connection with *Metridium*, but entirely on the giant *Metridium* from deep water. Ecologically, as well as taxonomically, it would appear that these two Pycnogonums are closely related, since the mud bottom association of deep water is most closely related to the wharf piling associations of the intertidal zone."

There is still a fourth specimen of this species in our collections, also collected and donated by Mr. Ricketts, from Pacific Grove, 1927.

Remarks.—*P. rickettsi* seems to be the only reticulated *Pycnogonum* known at present, in which the spines, or processes on the first three trunk segments, are individually much stronger than, and considerably exceed the ocular tubercle in height. *P. cataphractum*, in which the first of the median processes is larger than the ocular tubercle, is at once set apart by its very spiny legs.

In *P. mucronatum* the median row of spines or processes topping the trunk

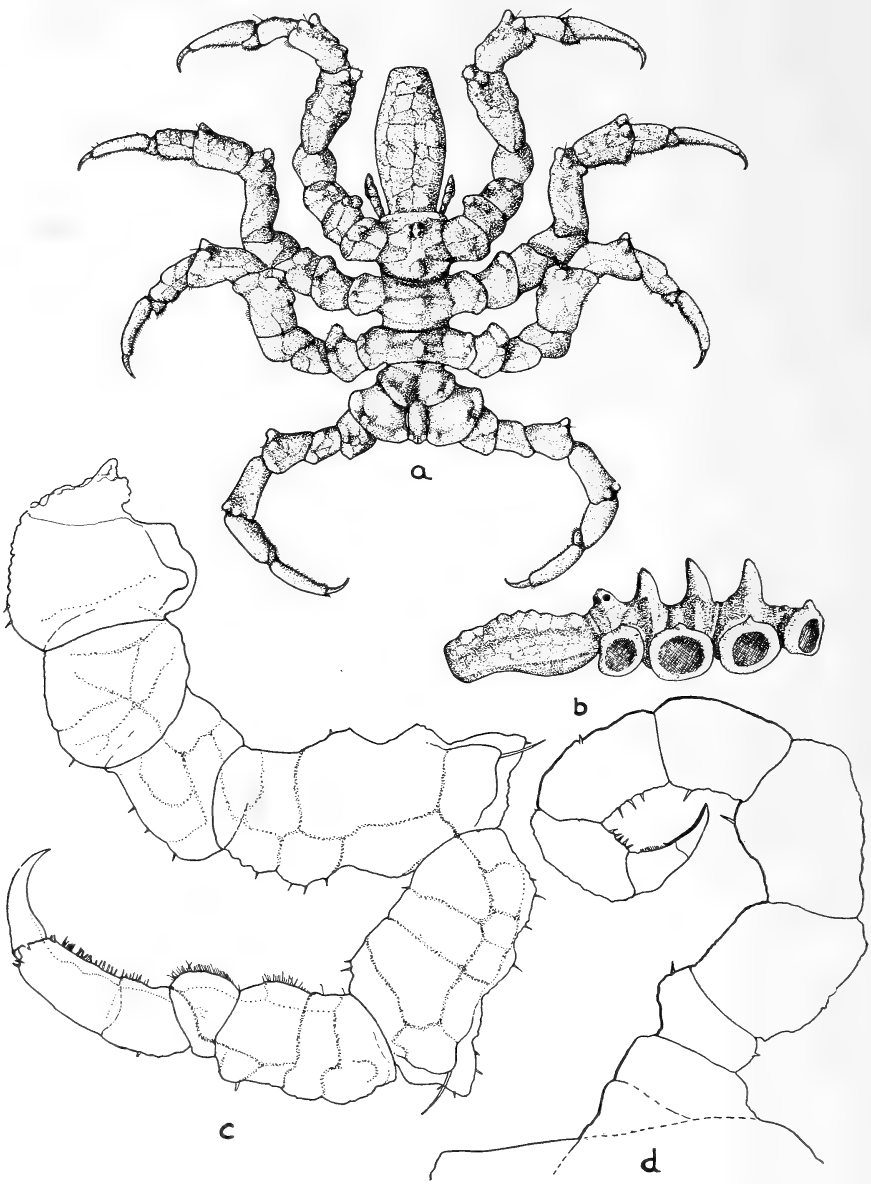

Fig. 1.—*Pycnogonum rickettsi*. *a*, Dorsal view of holotype, × about 8; *b*, Lateral view; *c*, Third right leg, × about 29; *d*, Oviger, × about 60.

segments are more or less subequal in height with the ocular tubercle, they may slightly exceed it but they are much less stout, indeed feeble in comparison; moreover, the very long slender spine-like processes topping the distal upper margins of the crurigers are quite distinctive of this species and readily set it apart from all others.

P. madagascarensis, which, regrettably, seems never to have been figured, has its proboscis in the shape of a truncate cone like *P. mucronatum*, but the median dorsal tubercles are low and not so elevated and columnar-appearing as in that species, while spines or tubercles on the crurigers above seem to be wholly wanting.

Pycnogonum hancocki, new species

A very striking reticulated species of light tan, with reticulation a deep rich red-brown color, contrasting sharply with the bright white articulating ends of the various joints. The ocular tubercle forms quite a conspicuous feature in the color pattern of this species because of its darker coloration and greater concentration of brown. This is due chiefly to the presence of the dark brown pigmented eye-spots and to the fact that two of the dark brown lines forming the reticulations divide the ocular tubercle roughly into four quarters.

The proboscis is subcylindrical, truncate, and a little narrower anteriorly than posteriorly. It is about $2\frac{1}{4}$ times as long as its greatest width. In length the proboscis is very slightly longer than the first two and half the third trunk segments taken together. The first trunk segment is equal in length to the second, third, and fourth taken together; its greatest width over the outermost angles of the crurigers equals the combined length of the first, second, and about a fourth of the third trunk segments taken together. The greatest width of the second segment is equal to the length of the first two trunk segments taken together. The third segment is about as wide as the length of the first trunk segment plus one-third the second. The posterior pair of crurigers are fused for a part of their length. The abdomen is about two-fifths the proboscis in length.

In line behind the only moderately high, rounded ocular tubercle are three rounded tubercles, each smaller and less robust than the ocular; of these the third on the third trunk segment is the larger; the first is situated on the hinder margin of the first trunk segment; the second of these three tubercles is but little larger than the first and, like it, is placed on the hinder margin of its, the second, segment. On the dorsum of the last trunk segment there is no eminence or raised place worthy of comment, under a higher magnification there appears to be a very slight elevation or swelling at about the midpoint of the center line.

The distal margins of the crurigers seem to be rather inconspicuously, slightly nodulated, or perhaps just a bit more coarsely granulated, than the rest of the body surface. The distal margins of the first coxae of all the ambulatory legs seem little swollen, there being a tiny nodule or tubercle either side of the brown line of the reticulations which divides the white area into two; at about the distal mid portion of the proximal half of the second coxae of the second and third legs there is a single small nodule of comparable size, the second coxa of the first leg seems without a trace of nodulation, while the second coxae of the fourth pair each carry a pair of

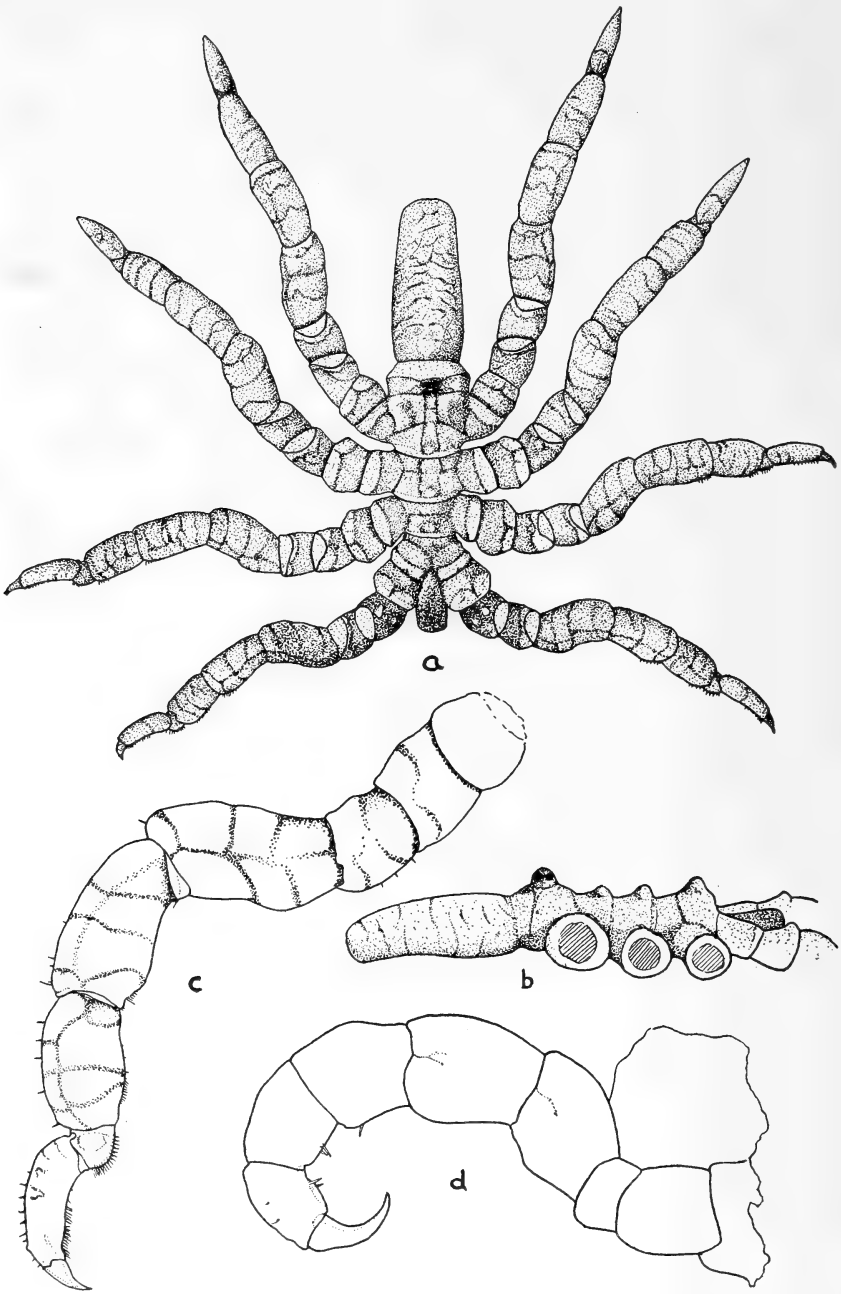

Fig. 2.—*Pycnogonum hancocki*. *a*, Dorsal view of holotype, × nearly 9; *b*, Lateral view; *c*, Third right leg, × about 19; *d*, Oviger of male, × about 70.

nodules or noticeable small rounded tubercles, one on the middorsal line, and the other transversely in line and a little behind the median axis of the coxa. The remaining joints of the ambulatory legs are rather uniformly finely granulate, as is the entire animal.

In the third right leg the three coxal joints are more or less sub-equal in length as are the femoral and the first tibial joints approximately; the second tibial joint and the second tarsal exclusive of the terminal claw are also of about the same length; measured on the ventral margin, the first tarsal joint is very little longer than the terminal claw; the second tibial joint is about two-thirds the length of the first, and either two coxal joints are equal to three-fourths the femoral joint in length. Much as in the preceding species, the inferior borders of the tarsal joints are finely spinulate, and to a lesser extent the tibial joints near their distal ends only.

Type and distribution.—The largest of four specimens before me, a female, has been taken as the type. It was taken Feb. 9, 1933, in company with a somewhat smaller male carrying eggs on its ovigers at Sta. 65, Hancock Galapagos Expedition, at low tide from a small rocky reef, offshore, north of Tagus Hill, Albemarle Island, Galapagos, latitude 0°14′ S. It measures approximately: proboscis 2.4 mm. long by 0.9 mm. wide; trunk, exclusive of posterior crurigers, 2.6 mm. long; and abdomen 1.0 mm.

The two other specimens at hand, both females, were taken respectively at Chatham Island, January 31, 1933, in the course of dredging in 2–3 fathoms east of Wreck Bay; and during shore collecting along the rocky shore east of Cormorant Point, Charles Island, Galapagos, February 6, 1933.

Remarks.—*P. hancocki* is one of the reticulated species of *Pycnogonum* belonging to the group having a few tubercles on the ambulatory legs. From the species so grouped, *P. indicum*, *madagascarensis* and *mucronatum*, it differs, in the case of the first, among other characters, in lacking the armed ridge running back from the ocular tubercle, and in having a subcylindrical proboscis instead of a decided conical one; the proboscis of *P. madagascarensis*, like that of *P. indicum*, forms an obtuse cone; in *P. mucronatum* the height of the median dorsal tubercle of the trunk serves to differentiate it from *P. hancocki*, aside from the fact that the former has long slender spinous or tubercular processes on the crurigers which are wholly lacking in the latter. The very low dorsal tubercles of the trunk segments of this species seem rather unique among the reticulated Pycnogonums, particularly those with legs comparatively or almost wholly free of noticeable tubercles.

Nymphon grossipes (Fabr.)

On occasion of a reconnaissance in the Bering Sea in the furtherance of the National Geographic Society's interest in the possibilities of aerial Arctic exploration, Capt. R. A. Bartlett made a number of dredgings for marine invertebrates. In one haul made about fifteen miles north of Big Diomede Island, Bering Strait, June 14, 1924, two specimens of *Nymphon grossipes* were obtained. The only previous records of this species off the West American coast are those of John

Murdoch at Point Franklin in 13½ fathoms and at the head of Norton Sound, Alaska, in 5 fathoms, respectively August 31 and September 12, 1883.

Phoxichilidium femoratum (Rathke)

A very ragged, yet identifiable, specimen of this species was received from the U. S. Biological Survey as a part of the stomach contents of *Histrionicus histrionicus pacificus* Brooks, the Pacific harlequin duck, collected by A. M. Bailey Sept. 1, 1920, at Stephens Passage, Alaska. At the time of its receipt, the specimen represented a noteworthy eastward and southward extension of the range for the species, which heretofore on the west coast of America had only been known to range from Unalaska to Orca (Cole). However, I have also had occasion to determine another specimen of this species from much farther south, from Ucluelet, Vancouver Island. This specimen is listed a second time below as one of the pycnogonids seen from British Columbia.

Ammothea latifrons Cole

A portion of fragments of sixteen specimens of this pycnogonid were determined for the Biological Survey from the stomach contents of the Pacific harlequin duck, *Histrionicus histrionicus pacificus* Brooks, taken by P. A. Tavener at Kiska Island, Aleutians, April 16, 1924.

Ammothea pribilofensis Cole

This species has been determined from stomachs of *Histrionicus histrionicus pacificus* Brooks, the Pacific harlequin duck, as well as *Somataria v-nigra* Gray, the Pacific eider, on several occasions in quantities of one to three specimens. The birds in which these identifiable specimens were found were secured by G. Dallas Hanna on St. Paul Island, Pribilofs, January 13 and 29, 1918, and Mar. 21, 1915.

In several other specimens of each of these two ducks, fragments of pycnogonids which could not be definitely named were found, as well as in a pigeon guillemot, *Cepphus columba* Pallas, also obtained by Dr. Hanna on St. Paul Island, Dec. 9, 1914. Hydroids of at least two species were found in the stomachs of several of the birds from which pycnogonids were sorted at the Survey. The remarkable variety of marine animals eaten by the ducks at least would indicate that the pycnogonids were very probably ingested along with the hydroids, some algae, crustacea, mollusks, echinoderms, and the like, which form the bulk of their varied fare.

PYCNOGONIDS FROM MONTEREY BAY, CALIFORNIA

As it may be of some interest, a list of the Monterey Bay pycnogonids that were identified a few years ago for Mr. E. F. Ricketts of the Pacific Biological Laboratories is here appended. Eight species are to be recorded from the region:

ANOPLODACTYLUS ERECTUS Cole, 1 specimen, collected in 1927, "from compound ascidians far out; tide pools."

HALOSOMA VIRIDINTESTINALIS Cole, 16 specimens, chiefly taken in 1928, "from wharf piling, *Obelia* colonies."

AMMOTHEA LATIFRONS Cole, 2 specimens "from 80 fathoms," received in 1928. These specimens seem to be of a somewhat more slender build as regards the appendages, eye-tubercle, and abdomen than most of those available for comparison from farther north. However, one from Sanborn Harbor, Nagai, Alaska, determined by Leon J. Cole, appears so well to link the California specimens to the species that I have so identified them in spite of what appears to be a very considerable extension of range southward.

AMMOTHELLA TUBERCULATA Cole, 1 young specimen, received 1927.

LECYTHORHYNCHUS MARGINATUS Cole, 3 specimens, data as for *A. erectus* above.

TANSTYLUM INTERMEDIUM Cole, 2 specimens, received in 1927.

PYCNOGONUM STEARNSI Ives, 9 specimens received in 1927. One of specimens was found on an anemone.

PYCNOGONUM RICKETTSI Schmitt, specimens and occurrence as given with the description of the species above.

PYCNOGONIDS FROM SOUTHERN CALIFORNIA

AMMOTHELLA BI-UNGUICULATA Dohrn, 3 specimens from San Pedro (Pt. White), collected by E. P. Chace, May 5, 1919.

AMMOTHELLA SPINOSISSIMA Hall, 1 specimen, as above, May 18, 1919.

PYCNOGONUM STEARNSI Ives, 13 specimens, collected by E. P. Chace; three males, one female, from tide pools, Point Fermin, Mar. 28, 1918; and three males, six females, from mussels, north of Santa Monica, Nov. 17, 1918.

PYCNOGONIDS FROM BRITISH COLUMBIA

From Ucluelet, Vancouver Islands, W. Spreadborough, May–July, 1909, sent in pycnogonids of four species for identification, while a fifth but tentatively determined was taken from Virago Sound, Queen

Charlotte Island, from 8–15 fathoms by M. Dawson, 1878. The specimens seen are as follows:

PHOXICHILIDIUM FEMORATUM (Rathke), 1 specimen.

AMMOTHEA GRACILIPES Cole, 4 specimens.

AMMOTHELLA TUBERCULATA Cole, 5 specimens.

? AMMOTHEA ALASKENSIS Cole, 1 specimen; close to if not identical with this species; from hydroids.

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

National Academy of Sciences.—A number of contributions were made by Washington scientists at the autumn meeting of the National Academy of Sciences at Cambridge, November 20 to 22. Dr. F. E. WRIGHT announced new data obtained in polariscopic examination of moonlight, and their bearing on the problem of the nature of the lunar rocks. Dr. C. G. ABBOT spoke on his recent discovery of a 23-year weather cycle, and its correlation with periods of sun-spot maxima. Dr. ARTHUR E. MORGAN, director of the Tennessee Valley Authority, delivered the principal evening lecture, on *Muscle Shoals and the Tennessee Valley Problem.* Dr. JOHN C. MERRIAM presented a review of the present status of the problem of the antiquity of man in North America. Gen. GEORGE O. SQUIER discussed a proposal for a combined sound and light distributor.

National Institute of Health.—Researches at the National Institute of Health and at the Rockefeller Institute for Medical Research in New York City indicate that encephalitis patients develop immune bodies in their blood. In both investigations a virus-susceptible strain of mice was used. The animals were inoculated with material from the brains of encephalitis victims, producing typical symptoms. But susceptible mice given preliminary injections of blood serum from encephalitis patients were protected from the disease.

The Colorists organized.—The artistic, commercial, scientific, and other aspects of color will be the concern of an informal group organized under the name of *The Colorists.* While color enters into many activities of daily life and is of interest to groups of artists, physicists, and industrialists in many aspects, Washington has not heretofore had a society whose primary object was color in all of its many aspects. At the organization meeting held at the Cosmos Club, CHARLES BITTINGER, Washington artist who has made a scientific study of color, presided. Miss DOROTHY NICKERSON, color expert of the Bureau of Agricultural Economics of the Department of Agriculture, was also one of the leading organizers. Among those who participated in the formation of the organization were Dr. E. C. CRITTENDEN, assistant director of the U. S. Bureau of Standards, and Mr. A. E. O. MUNSELL of the Munsell Research Laboratory, Baltimore, Md., who has been a leader in the commercial standardization of color. The U. S. Bureau of Standards was also represented by Dr. K. S. GIBSON, Dr. DEANE B. JUDD, R. T. MEASE, J. T. BREWSTER, WILLIAM D. APPEL, R. S. HUNTER, Dr. PERCY A. WALKER,

Miss RUBY K. WORNER, Miss GENEVIEVE BECKER, and Dr. H. D. HUBBARD. Among the representatives of the U. S. Department of Agriculture were: B. A. BRICE, M. R. COE, C. C. FIFIELD, PAUL E. HOWE, GEORGE PFEIFFENBERGER, CHARLES E. SANDO. From the University of Maryland came Dr. BEAUMONT and LEE SHRADER. The Paint and Varnish Institute was represented by L. P. HART, J. R. STEWART, G. G. SWARD and A. W. OAN. Dr. T. S. BRACKETT and Dr. E. D. MCALISTER attended, representing the Division of Radiation of the Smithsonian Institution. Dr. S. W. BOGGS, geographer of the State Department and Miss EDNA S. BANKS of the Library of Congress Map Division represented geographical interest. Lieut. BERN ANDERSON mentioned the color problems of the U. S. Navy. Other Washington fields of color interest were represented by CHARLES VAL CLEAR, director of the Art League, I. H. GODLOVE, color counselor, and FELIX MAHONEY, artist.

National Zoological Park.—A "ghost wolf" (*Chrysocyon jubatus*) from Brazil has been acquired by the National Zoological Park. The animal, which is about five months old, is believed to be the only one in captivity. The National Zoological Park has also started a collection of birds whose names are familiar in English literature; it includes specimens of the English robin, European shrike, goldfinch, chaffinch, hawfinch, bullfinch, lapwing and waxwing. Specimens of the bulbul and shamas thrush, Asiatic birds also often mentioned by English authors, are also included.

National Bureau of Standards.—On the evening of Saturday, November 18, the members of the staff of the Bureau of Standards gave a reception in honor of Dr. LYMAN J. BRIGGS, the new Director of the Bureau. In addition to staff members there were in attendance the Secretary of Commerce and the heads of the scientific bureaus of the Government. An exhibit of recent developments in science was arranged in connection with the reception.

PERSONAL ITEMS

Dr. GUNTHER ROEDER, director of the Pelizaeus Museum, Hildesheim Germany, lectured before the Archaeological Society of Washington on discoveries made by his expedition at Hermopolis, in Egypt.

Dr. WILLIAM WALLACE CAMPBELL, president of the National Academy of Sciences, president emeritus of the University of California and director emeritus of the Lick Observatory, was the principal speaker at the annual Carnegie Day exercises of the Carnegie Institute of Technology on November 28.

Dean A. A. POTTER of Purdue University has been added to the committee on railway research of the Science Advisory Board.

Dr. W. F. G. SWANN, director of the Bartol Research Foundation of the Franklin Institute, Philadelphia, gave a cello recital before the Arts Club of Washington on the evening of Thursday, December 14.

Dr. KARL F. KELLERMAN has been appointed head of a new division of plant disease eradication and control in the Bureau of Entomology, U. S. Department of Agriculture.

FREDERICK D. RICHEY, now in charge of corn investigations in the

Bureau of Plant Industry, has been promoted to be associate chief, effective January 1.

Dr. JAMES ROBERTSON, director of the Nautical Almanac office of the Naval Observatory, was given the degree of Doctor of Science by Georgetown University on the evening of Friday, December 24. Among those who witnessed the ceremony was the Rev. E. C. PHILLIPS, S.J., formerly astronomer at Georgetown and now Father Provincial of the Baltimore Province of the Society of Jesus.

Dr. W. B. BELL, of the Bureau of Biological Survey, attended the 47th annual convention of the Association of Land Grant Colleges and Universities, at Chicago, Ill.

RICHARD KILBOURNE, forester for the Extension Service of the University of Maryland during the last three years, has resigned to become assistant chief of planting in the forestry department of the Tennessee Valley Authority at Knoxville.

W. C. HENDERSON, associate chief of the Bureau of Biological Survey, spoke over the radio on the subject, *A critical time for ducks and geese,* on November 12. His talk was broadcast by Station WMAL in Washington. He pointed to overshooting as one of the chief causes of the decrease in waterfowl and the only one that can be remedied immediately.

Park Naturalist PAUL R. FRANKE of Mesa Verde National Park and Park Naturalist D. S. LIBBEY of Crater Lake National Park are in the Washington Office at the present time. Mr. FRANKE will remain in Washington for several months assisting with the motion picture program being lined up for the Civilian Conservation Corps camps by the Branch of Research and Education. Mr. LIBBEY will also remain in the Washington Office for several months to assist with the Emergency Conservation Work program being carried out in the reservations under the jurisdiction of this office.

Mr. EARL A. TRAGER, geologist in the branch of research and education, office of National Parks, Buildings and Reservations, U. S. Department of the Interior, will give a talk on the geology in the national parks at the forthcoming meeting of the Geological Society of America to be held in Chicago at the end of December.

F. P. PARRIS and E. M. SHOOK of the department of historical research, Carnegie Institution of Washington, received training in December at the department of terrestrial magnetism in making astronomical observations for the determination of latitude and longitude and in observing the magnetic declination preparatory to taking up work in connection with the proposed archaeological excavations in Central America.

Mr. JASON R. SWALLEN, assistant agrostologist, Bureau of Plant Industry, sailed Nov. 22 for Pará, Brazil. He will spend six months collecting and studying grasses in the states of Pará, Maranhão, Piauhy, Ceara, and Rio Grande do Norte. The grasses of this region are very little known, the few botanists who have visited northeastern Brazil having as a rule neglected the grasses.

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This JOURNAL, the official organ of the Washington Academy of Sciences, publishes: (1) short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The JOURNAL is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years.

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JOURNAL
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Vol. 24 February 15, 1934 No. 2

BOTANY.—*Two new varieties of* Salix scouleriana *Barratt.*[1] Carleton R. Ball, University of California.

The well marked but variable species complex known as *Salix scouleriana* is distributed from New Mexico and southern California to the Yukon Valley of Canada and Alaska. In altitude it ranges from sea level along the Pacific Coast, from California to Alaska, to elevations of 8000 or 9000 feet in the southern part of the Rocky Mountains and in the San Bernardino Mountains of California.

It has been described under several specific names, including *S. scouleriana* Barratt (1839), *S. flavescens* Nuttall (1841), *S. stagnalis* Nuttall (1841), *S. brachystachys* Bentham (1857) and *S. capreoides* Andersson (1858). Probably some of the plants so named represent distinguishable varieties, but none of them is so recognized as yet. This is due in part to the difficulties of current herbarium material. It is a species of extremely precocious flowering and the promptly deciduous aments fall before the leaves develop. Some plants flower in December on the Pacific Coast. Except in the rare cases where collections are made from the same plant at intervals of some weeks, therefore, it is almost impossible to know what observed leaf forms are associated with certain ament and flower characters. The species certainly would be better understood if it could be split into varieties. Happily it now is possible to segregate and describe two varieties hitherto unrecognized.

The writer desires to express thanks for the many courtesies received from the staff of the Department of Botany, University of California.

Salix scouleriana var. **coetanea** Ball, var. nov.

Sectio Capreae. A specie typica amentis coetaneis, pistilliferis iis speciei aliquando laxioribus, et ambobus in pedunculis brevibus folioso-bracteatis fultis differt.

[1] Received October 17, 1933.

Shrub usually 2–4 or rarely 5 m. high. Branchlets rather slender, fragile (or readily deciduous in drying), divaricate, the 2-year brown to dark brown and glabrate to glabrous, the 1-year and seasonal shoots yellowish to brown and usually finely and often sparsely puberulent. Bud scales small, colored and clothed as the branchlets. Stipules wanting, or rarely 2–5 mm. long on vigorous shoots, broadly lanceolate, dentate, puberulent. Blades oblanceolate and acutish to obovate and obtuse or rounded at apex, cuneate at base, 3 to 5 cm. long by 1.5–2.5 cm. wide, or the larger up to 6 by 3 cm., entire and slightly revolute on the margins or the distal on seasonal shoots irregularly crenulate-denticulate, dark green above, glaucescent to glaucous beneath, puberulent on both surfaces (probably becoming glabrate in age).

Aments coetaneous, borne on short, leafy-bracted peduncles, the staminate peduncle about 5 mm. long, with small bracts, the pistillate peduncle 5–15 mm. long and bearing 3–5 small leaf-like bracts, 0.5–2 cm. long. Staminate aments 1–2 cm. long, Pistillate aments 1.5–4 cm. or sometimes 5 cm. long; pedicels of the capsules 0.5–1 or 1.5 mm. long; styles short, stigmas elongated, 1 mm. long, usually entire. Flower scales in both sexes elliptical-obovate, acutish to rounded, black, longvillous.

This is a shrub with the general characters of *S. scouleriana*, but differing from type concept of that species and the next variety in having the aments coetaneous, the pistillate rather lax, and both sexes borne on short, leafy-bracted peduncles. For the material on which the description is based, botanists are indebted chiefly to two very discriminating collectors, Joseph P. Tracy of Eureka, California, and J. William Thompson of Seattle, Washington. The writer is glad to acknowledge his personal obligation to both.

As will be noted from the specimens cited, variety *coetanea* flowers from May to June, and fruit may be found during June and early July, in marked contrast to the early spring flowering of the species. Even at sea level, flowering did not occur until mid-March. There must be admitted the possibility that this condition results from physiological disturbance of the plant. The increasing number of collections, over a wide area, however, make this unlikely. The type specimen (pistillate) is Thompson No. 9297 in herbarium C. R. Ball (2 sheets).

So far as available material indicates, this variety is confined to the central part of the range of the species. It occurs sparingly from northwestern California to Nevada and Utah, and north to south-central Washington, western Montana, and the mountains in the southern parts of Alberta and British Columbia. It is found, therefore, in the Wasatch, Rocky, Sierra-Cascade, and Coast Range mountain systems. Except for the one collection near the ocean, where precipitation and fog maintain low temperatures, the collections are all from elevations of 4000 to 6000 feet. It seems probable that the variety will be found to have an even wider range.

Specimens examined are cited below. The containing herbariums are: CRB, Carleton R. Ball; NMC, National Museum of Canada; PC, Pomona College; UMont. University of Montana; and UC, University of California.

CALIFORNIA: Humboldt Co. Ferndale, alt. 100 ft., shoots from cut and

burned stump, *Joseph P. Tracy* 10921, (UC). Trinity Summit, shrub 10 ft. tall, on dryish slopes back from the meadows, Corral Prairie, alt. 5000 ft., *Joseph P. Tracy* 10507, (CRB, UC); shrub with erect branches, 15 ft. tall, at edge of meadow, same locality, *Tracy* 10518 (UC). Trinity Summit, common shrub in moist places, 6–10 ft. tall, rocky, exposed places, head of Devil's Hole, alt. 6000 ft., *Tracy* 10694, (CRB, UC). Trinity Summit, rocky exposed places, head of Brett Hole, alt. 6000 ft., *Tracy* 10714, (UC). Modoc Co. In lodgepole pine woods, north slope of Bidwell Mtn., Warner Mts., *Elmer I. Applegate* 7619, (CRB).

NEVADA: Head of Fall Creek, Ormsby Co., elev. 2460 m., *C. F. Baker* 1153, (PC; distrib. unnamed; ♀ and ♂, the latter aments 1 cm. long, the peduncles 0.5 cm. and bracted). Lake Tahoe, Nevada, *M. E. Jones*, (PC, distrib. unnamed; fruit past ripe).

MONTANA: Missoula, on trail to Mt. Stuart, alt. 6000 ft., *J. E. Kirkwood* 1076, (UMont, UC).

WASHINGTON: Kittitas Co. Upper alpine slopes of Redtop, alt. 4500 ft., *J. Wm. Thompson* 9297, (CRB, UC, luxuriant growth, leaves green beneath from artificial drying); same locality, alt. 4000 ft., *Thompson* 9303, (CRB, UC; "more robust than 9297, and occupying a definitely lower zone"). Chelan Co. Blewett Pass, Wenatchee Mts., abundant in thin timber on open hillsides, elev. about 4200 ft., *C. R. Quick*, 1057, (♀, ♂), (CRB, UC).

UTAH: La Sal Mts., *M. E. Jones*, (PC). City Creek Canon (Ogden?), *M. E. Jones* (PC).

BRITISH COLUMBIA: International Boundary Commission. Near International Boundary between Midway and Osoyoos, first summit west of Skagit River, *J. M. Macoun* 73683 (NMC). Mons, Pacific Great Eastern Ry., *J. M. Macoun* 97789, 97790 (NMC).

ALBERTA. Banff and vicinity, *N. B. Sanson*, 19, 145, 161 (CRB).

SALIX SCOULERIANA var. **thompsoni** Ball, var. nov.

Salix brachystachys Bentham, *S. scouleriana tenuijulis* Andersson (in part) Monog. Sal. Kon. Svensk. Vet.-Akad. Handlingar **6**: 83. 1867.

S. brachystachys, β scouleriana, 1. *tenuijulis* Andersson (in part). DC. Prodr. **16**(2): 225. 1858.

Sectio Capreae. A forma typica differt ramulis gracilioribus, strictioribus, et glabrescentioribus, foliis minoribus plerumque anguste ellipticis vel anguste oblanceolatis, 3–7 cm. longis, 1–2 cm. latis, plerumque plus minusve crenato-denticulatis, et amentis minoribus gracilioribus, 1–2.5 cm. longis.

Differs from the species in the slender, elongated, more glabrate branchlets, the small and slender aments, and the small, mostly narrowly oblanceolate, and usually more or less crenate-denticulate leaves.

Shrub 2–4 or sometimes 6 m. high, branchlets usually slender, elongated, straightish, ascending, and tough; 1-year and 2-year branchlets usually black or dark brown, glabrous and often shining; seasonal shoots pubescent or puberulent, becoming glabrate; bud scales 4–7 mm. long, colored and clothed as the shoots bearing them; stipules usually wanting, or 1–2 mm. long and semi-cordate on vigorous shoots; petioles 5–10 mm. long, pubescent to glabrous; leaf-blades relatively small, those on seasonal shoots and the upper leaves on 1-year and 2-year branchlets narrowly elliptical to oblanceolate, commonly 1 by 3, 1.2–1.5 by 4, 1.5–1.8 by 5–6, and 2.5 by 7.5 cm. in

size; the lowermost on these branchlets broadly oblanceolate, commonly 1.5 by 3–3.5 and 2 by 4 cm. in size; all usually cuneate at base; narrower blades acute or short-acuminate, lower and broader often obtuse; the upper narrower irregularly and often prominently crenate-denticulate, the lower entire or subentire; all green and glabrous above or the younger puberulent,

Fig. 1.—*Salix scouleriana* var. *thompsoni* Ball. Portion of pistillate and staminate cotype specimens.

all pale green to subglaucous beneath, the older glabrous to glabrate, younger pubescent or occasionally tomentose beneath with gray hairs which often become somewhat rusty in color.

Staminate aments 1–2 cm. long, almost sessile; stamens two, filaments free, glabrous; scales usually somewhat narrower than those of the pistillate flower. Pistillate aments 2–3 cm., or occasionally 4 cm. long at maturity, usually slender and incurved, on tomentose peduncles 5–7 mm. long and

bearing 2–3 pilose bracts or small, bract-like leaves; capsule lance-rostrate, 6–7 mm. long, gray-pubescent, borne on a pubescent pedicel 1–1.5 mm. long; style very short, 0.2–0.5 mm. long; stigmas entire or divided, 0.5–1 mm. long; scales broadly oblanceolate or obovate, 1.5–2.5 mm. long, acute to obtuse or sometimes slightly erose at apex, black, densely pilose on outside and thinly pilose inside with long, shining hairs.

The existence of the well marked variation described above has been known for several years but publication has been delayed until the collection of flowers and foliage from the same plants should make possible a complete and accurate description. This convincing material has now been made available by Mr. J. William Thompson, of Seattle, whose critical collections are adding rapidly to the known flora of this large and diverse State. It is a real pleasure to name this variety in his honor.

The portion of the *scouleriana* complex to which variety *thompsoni* is most closely related is the variety or form *tenuijulis* described by Andersson, as cited at the opening of this discussion. From Andersson's form it differs in still smaller aments and foliage and especially in elliptical or elliptical-oblanceolate and denticulate leaves, as well as in much less pubescence on branchlets and leaves.

The center of distribution for this variety appears to be the Puget Sound area of Washington and the Georgian Bay area of adjacent British Columbia. It has been found by Pammel on the Oregon Coast below the mouth of the Columbia River. Away from the coast it has been taken at appreciable elevations in the Cascade Mountains, at Easton, Washington, by Pammel and on Mt. Benson, Vancouver Island, by John Macoun. Doubtless the known range will be extended still further when these facts come to the attention of collectors.

The initials of the herbariums containing the specimens cited below are: CRB, Carleton R. Ball; NMC, National Museum of Canada; UC, University of California; and USN, United States National Herbarium. The following specimens have been examined:

OREGON: Clatsop Co. Gearhart Park, *L. H. Pammel* 13, (CRB).

WASHINGTON: King Co. Seattle: *Piper and Smith* 556 (in part), (CRB); *C. V. Piper*, March, 1890 (CRB); about 3 miles north of city limits, *C. V. Piper* 6682, 6686, 6693, (CRB); moist slopes along Cheasty Boulevard, *J. William Thompson* 5896 (pistillate type collection), 5898, 5900 (staminate type collection), 5901, (CRB). Pierce Co. Tacoma, shrub, 10–20 ft. high, common in gravelly soil, *J. B. Flett* 1884, March 6, April 14, and June 14, 1901 (CRB); abundant in vacant lots, dry places, *J. B. Flett* 2272, 2272a, (CRB); *L. H. Pammel* 34, (CRB). Kittitas Co. *Easton, Pammel and Dudgeon* 19, (CRB). Snohomish Co. Marysville, *J. M. Grant* 208, 209, 211, (CRB); 203, (CRB, UC, *sub nomen S. caudata*). San Juan Co. Lopez Island, shrubs 6–9 feet high, dry roadsides near the "Holy Roller" colony, Hunter's Bay, *C. R. Ball* 2084, (CRB).

BRITISH COLUMBIA: Vancouver Island. Cowichan Lake, *W. Spreadborough* 83853, (NMC). Departure Bay, *W. Spreadborough* 2, (NMC, 83847 and

83857); 3, (NMC, 83846 and 83854); 4, (NMC, 83845 and 83848); 5, (NMC, 83844 and 83849); 6, (NMC, 83843). Mt. Benson, upper slopes, alt. 3200 ft., *John Macoun* 76800, (CRB, NMC). Nanaimo and vicinity, *John Macoun* 76802, (CRB, NMC); in thickets, *John Macoun* 80958, (NMC); *John Macoun* 76804, (NMC); *W. Spreadborough* 15, (NMC 83850). Strathcona Park, Drumm Lake, *J. M. Macoun* 83881, (NMC). Victoria and vicinity, *John Macoun* 76770, (CRB, NMC); in thickets, Burnside Road, *John Macoun* 76766, (NMC); Beaver Lake, *John Macoun* 76801, distributed as *S. geyeriana* (CRB, NMC, branchlets very short, crowded); *A. J. Pinio* 68682, (NMC); *M. O. Malte* 122135, (NMC, UC). Georgian Bay Islands. Mayne Island, *J. M. Macoun* 90155, (NMC). Salt Spring Island, wet places, *John Macoun* 24470, (NMC, UC). New Westminster District. Ocean Park, 3 miles north of 49th parallel, gravelly hillsides on logged and burned land, *J. K. Henry* 6, (CRB, 3 sheets; NMC, 2 sheets); *Henry* 7, (CRB, 3 sheets; NMC, 2 sheets); *Henry* 12, (CRB, NMC). All distributed unidentified, NMC Nos. 117206–117209, and 117211. Powell River, erect bushes, 8–10 ft. high, *J. G. Jack* 2838, (CRB).

ZOOLOGY.—*Two new species of pearly fresh-water mussels.*[1] WILLIAM B. MARSHALL, U. S. National Museum. (Communicated by PAUL BARTSCH.)

The recent pearly fresh-water mussel described herein comes from southern Paraguay and belongs in the genus *Anodontites.* The fossil species comes from the State of Monagas, Venezuela, and is the type of a new genus, *Castalioides.*

Castalioides, new genus

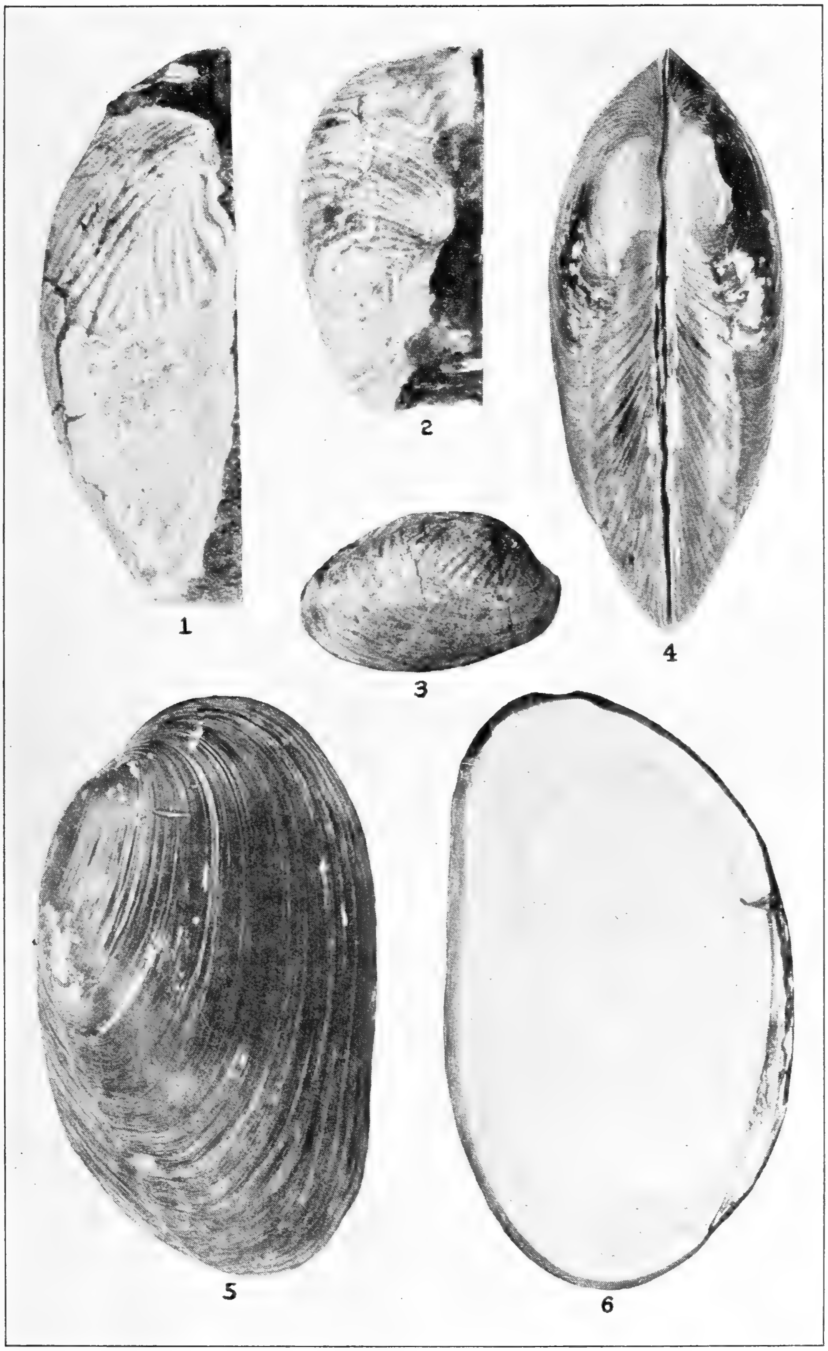
Shell with strong sculpture of radial ribs, several of the innermost pairs arranged to form very long V's. Ribs crossing the anterior and posterior slopes form a divaricate pattern with the radial ribs.

Type: *Castalioides laddi* described below.

Castalioides laddi, new species

Shell subelliptical, slightly inflated. Beaks set well forward (at about the first one-quarter of the length). Dorsal margin arcuate; anterior margin rounded and rounding into the ventral margin which is slightly arcuate and joins the posterior margin in a sharp curve. Posterior end obliquely subtruncate. Anterior ridge not differentiated from the general surface except by the divaricating sculpture along it. Posterior ridge high, subangular. Posterior dorsal area rather broad. Sculpture of strong, nearly straight, radial ribs, several of the innermost pairs joining to form very elongate V's with the apex pointing toward the ventral margin. Distant from the beaks the ribs become somewhat irregular. Several low ribs originating on the posterior

[1] Published by permission of the Secretary of the Smithsonian Institution. Received October 6, 1933.



Figures 1–6.

Figs. 1–3. *Castalioides laddi.* Fig. 1.—Posterior sculpture of type ×2. Fig. 2.—Anterior sculpture of type ×2. Fig. 3.—Right valve. Natural size.

Figs. 4–6. *Anodontites schadei,* type specimen. Natural size.

ridge and divaricating there from the general radial sculpture, run across the posterior area. Similar, but smaller, more sharply defined ribs divaricate from the general sculpture near the anterior ridge and run across the anterior area. (Teeth not showing in the type, but judging from imperfect teeth showing in a right valve paratype, they resemble those of *Tetraplodon linki* Marshall.)

The type, U. S. National Museum (Cat. No. 373033) measures: Length, 40 mm.; height, 22 mm.; diameter (about 24 mm.). It and a paratype (Cat. No. 373034) were found fossil near Aragua de Maturin, capital city of the District of Piar, State of Monagas, Venezuela. This locality is on the Aragua River, a tributary of the Guarapiche River, which in turn is tributary to the San Juan whose waters drain into the Gulf of Paria, formed by the mainland of Venezuela and the Island of Trinidad. Two other paratypes were returned to the Venezuela Gulf Oil Co. from which the material was received. The geological age quoted for the specimens is Quaternary.

In general appearance the species resembles *Tetraplodon linki* Marshall[2] (Proc. U. S. Nat. Mus. **69**: 6, *plate 1, figs. 6, 7; plate 3, fig. 2.* 1926), but is distinguished generically and specifically by the divaricated sculpture along the anterior and posterior ridges. The species is named for Dr. Harry S. Ladd, through whose kind efforts the material was obtained.

Anodontites

Four specimens of this genus, all in bad condition, retain enough of their features to show that they are related to the group including such species as *A. tortila* Lea, *A. lacteola* Lea, *A. palmeri* Marshall and *A. pittieri* Marshall, all of which are recent species from the northern coast of South America.

Anodontites schadei, new species

Shell of medium size, rather heavy, oblong; dorsal margin lightly arched; ventral margin nearly straight, sloping upward at the anterior end and fading into the sharply rounded anterior margin; posterior margin oblique, slightly arched and forming with the ventral margin a widely rounded point which points downward, giving the shell a rather oblique appearance. Beaks eroded, located well forward, making the shell appear to hunch forward. Anterior ridge rounded, the descent to the anterior margin abrupt. Posterior ridge low, rounded, the descent to the posterior and dorsal margins rather steep. A well-marked riblet traverses the posterior area from the beaks to the rear extremity of the shell. Sculpture consisting of fine concentric growth striae, with a number of major rest periods prominently marked by deep concentric grooves. Centre of shell nearly smooth, posterior area and around the margins somewhat lamellate. Color chestnut, dark greenish near the beaks, the colors darker on the front half of the shell. Interior whitish, highly iridescent in the adductor scars and in the area between the pallial line and the margins. Anterior scar deep, posterior scar well-impressed. Pallial line 15 mm. from ventral margin. Prismatic border dark greenish olive, rather wide throughout but widest along the middle of the ventral margin. Sinulus narrow and long, its tip curving backward.

The type (U.S.N.M. No. 434732) measures: Length, 90 mm.; height, 53

[2] Von Martens in letter to Pilsbry (Princeton University Expeditions to Patagonia, 1896–99, 3: 610. 1911) says the generic name *Tetraplodon* is a synonym of *Castalia*.

mm.; diameter, 34 mm. It and a paratype (No. 424837) come from the Tubicuary River at Aroja in southern Paraguay, and were collected by Mr. F. Schade for whom the species is named and were presented by Mr. Hugh Fulton of London. The Tubicuary River is a tributary of the Paraguay about 65 miles above its confluence with the Parana and hence is in the La Plata system.

The nearest relative of *Anodontites schadei* is *A. mansfieldi* Marshall of the Rio Yaguaron and its branches, in Cerro Largo, Uruguay. *A. mansfieldi* is lighter in weight, proportionally more elongate, has the sinulus broad and curving forward, the interior typically rosy, the posterior end well-elevated above the ventral margin, and the prismatic border much wider, approaching in character the very wide prismatic border of *Anodontites patagonica* Lam. In addition to these differences, the two species come from different drainage systems.

ZOOLOGY.—*A new genus of Trematodes belonging to the subfamily Allocreadiinae.*[1] EDWIN LINTON, University of Pennsylvania. (Communicated by PAUL BARTSCH.)

In the manuscript of a paper: *Some Trematodes of fishes, mainly from the Woods Hole region,* awaiting publication, a new generic name is proposed to accommodate distomes, recorded in earlier papers by the author under the name *Distomum vitellosum.* To avoid possible confusion in nomenclature it has been suggested that a brief description of the new genus be published.

Cymbephallus Linton, gen. nov.

Body smooth, moderately elongate; ventral sucker surrounded by a raised border of the body wall, which may be more or less scalloped, papillate, or slightly fimbriate; cirrus very short, appearing as a muscular sucker at the orifice of the ejaculatory duct in front of the ventral sucker, to the left of the median line. Testes smooth or lobed, median, one following the other, behind the smooth or lobed ovary. Vitellaria diffuse.

Type species, *Cymbephallus vitellosus* (Linton).

CYMBEPHALLUS VITELLOSUS (Linton).

Distomum vitellosum Linton. Bull. U. S. Fish Com. 1899: 290, 416, *fig. 38, 39,* and *333–340.* Bull. U. S. Fish Com. 1904: 335. Proc. Nat. Mus. **33**: 105.

These distomes assume a great variety of contraction shapes. Living examples are usually relatively short with breadth one-third or more of the length. When placed in fresh water or weak formalin they tend to become turgid and may elongate until the length is six or more times the breadth. Under pressure the living worm may become several times as long as broad. Neck short, conical, often reflected dorsad, especially in turgid specimens;

[1] Received October 18, 1933.

posterior end of body frequently tapering to a blunt point. Ventral sucker larger than oral, ratio about 8:5, surrounded by a raised border, which may appear to be sinuous in outline, or to bear 4 or 5 lobes on the posterior border and about 4 on the anterior border, often inconspicuous in mounted specimens. In turgid specimens the ventral sucker is prominent, often more or less pedicellate. Maximum length in balsam about 3.5 mm. Pharynx usually a little longer than broad, ratio of length of pharynx to diameter of oral sucker about 4:5. Prepharynx very short or none; esophagus as long or longer than pharynx; intestinal rami reach nearly to the posterior end of the body, usually hidden by the dense vitellaria. Genital pore in front of the ventral sucker to the left of the median line; the ejaculatory duct terminates in what has the appearance of a strong, muscular sucker-like structure, at the anterior border of which is the opening of the metraterm. The seminal vesicle extends one-third or more of the distance between the ventral sucker and the ovary. The two testes, the one following the other, lie about midway between the ventral sucker and the posterior end. They are usually circular or oval in outline, occasionally subtriangular and rarely slightly lobed. Ovary near anterior edge of first testis usually more or less elliptical in outline. Vitellaria diffuse, continuing from near posterior edge of ventral sucker to the posterior end of the body, often obscuring the other organs. Uterus between ovary and ventral sucker. Ova, average of 24 specimens from 16 different specific hosts, in balsam, 0.053 by 0.029 mm.; maximum 0.063 by 0.033, minimum 0.045 by 0.027.

Recorded from 34 species of Woods Hole fishes, from 15 species of Beaufort fishes and from 5 species of Bermuda fishes. Found in the intestines.

Cymbephallus fimbriatus Linton, sp. nov.

Distomum vitellosum Linton, Bull. U. S. Fish Com. 1899: 462. Bull. U. S. Fish Com. 1904: 388, 390, 399, *fig. 176–178.*

Body elongate, not varying much in diameter; neck short, more or less conical; ventral sucker larger than oral, prominent, sometimes pedicellate, surrounded by a border of short papillae; pharynx elliptical-ovate, longer than broad; esophagus longer than pharynx; intestinal rami extend to posterior end; genital pore in front of ventral sucker, on left of median line, the opening of the ejaculatory duct a strong, muscular sucker; opening of the metraterm with sphincter on blunt papilla at anterior border of genital sucker; seminal vesicle elongate, curved, extending from one-third to more than one-half the distance between the ventral sucker and the ovary; testes two, the one following the other with but a short interval between, in some cases lobed, in others lobes not distinct; ovary at or near the anterior edge of the first testis, usually not lobed, although a tendency to lobing was observed in a few cases. Vitellaria diffuse, filling the body back of the testes, and extending to a point about half way between the ovary and the ventral sucker. Ova about 0.06 by 0.03 mm. Maximum length, in balsam about 5 mm.

From *Menticirrhus saxatilis*, Woods Hole; from *Bairdiella chrysura*, *Menticirrhus americanus* and *Sciurus ocellatus*, Beaufort. Found in the intestines.

This species differs from *C. vitellosus* in its larger size, and in having longer and more numerous papillae bordering the ventral sucker, in the lobed

character of the testes and larger ova, also in that the seminal vesicle extends farther back of the ventral sucker, and the vitellaria do not reach to a point as near the ventral sucker. Furthermore while *C. vitellosus* tends to taper towards the posterior end, *C. fimbriatus,* as a rule, maintains its breadth back of the ventral sucker and is bluntly rounded at the posterior end. There are, however, many contraction shapes in both species which make it difficult to fit descriptions to them.

ORNITHOLOGY.—*Bird bones from Eskimo ruins on St. Lawrence Island, Bering Sea.*[1] HERBERT FRIEDMANN, U. S. National Museum.

During several seasons of excavating ancient and more modern Eskimo habitations on St. Lawrence Island, Mr. H. B. Collins, Jr., Assistant Curator of Ethnology, United States National Museum, amassed a large collection of avian bones. Inasmuch as all his material was carefully collected with full stratigraphical data, it is possible to determine, in a relative sense, the different ages of the various specimens. Furthermore, since the time limits range from village sites abandoned half a century ago to some probably 2500 or more years old, the ages of the diggings vary appreciably. Of course, while 2500 years means a great deal in human cultural biology, it is of little moment as far as birds are concerned. The collection totals several thousand bones, all of which have been carefully studied and identified and are reported on in this paper. The bones are referable to 45 species of which 10 are new to the known avifauna of St. Lawrence Island. These 10 are as follows:

PUFFINUS TENUIROSTRIS	Slender-billed Shearwater
BRANTA CANADENSIS MINIMA	Cackling Goose
BRANTA NIGRICANS	Black Brant
MELANITTA DEGLANDI	White-winged Scoter
MELANITTA PERSPICILLATA	Surf Scoter
MERGUS MERGANSER subsp.	Merganser
HETEROSCELUS INCANUS	Wandering Tattler
LARUS CANUS BRACHYRHYNCHUS	Short-billed Gull
RISSA BREVIROSTRIS	Red-legged Kittiwake
BRACHYRHAMPHUS BREVIROSTRIS	Kittlitz's Murrelet

In addition to these, several species previously recorded on the basis

[1] Published by permission of the Secretary of the Smithsonian Institution. Received October 9, 1933.

of observational records alone, are represented in the present collection.

These bones, together with the collection of birds reported on in a previous paper (Proc. U. S. Nat. Mus., **80,** art. 12: 1–31. 1932.) give a fairly comprehensive picture of the avifauna of the island. Perhaps the most striking single feature is the complete absence of any species of ptarmigan, although both the Alaskan and the Siberian mainlands and most of the islands between them are inhabited by one or more forms of these birds.

In attempting to analyze the data from the viewpoint of ornithology, rather than ethnology or anthropology, we must remember that the number of bones of a given species is not a reliable index to the abundance of that species with respect to another, less abundantly represented, as the factor of human selection plays a large rôle. Thus, there are no raven bones in the present collection, but this does not mean that there were no ravens on the island at the time when the old villages were flourishing; it only means that Eskimos did not look upon ravens as food and did not kill them and leave their bones in and around their huts. On the other hand, it is obviously unlikely that the Eskimos would have been able to get numbers of birds of species that were rare at the time, so an abundance of remains does indicate a high numerical status for the species. It is the relative abundance of species that is chiefly affected by the element of selection. (By selection is meant not only the volitional choice of the Eskimo, but also his ability to procure the bird in question. Thus, a strong flying species that feeds over the open ocean, and relatively seldom roosts on the cliffs on the island would be very difficult to get and so, while desired by the Eskimo, might be "selected out" by his inability to get it.) Also some selection was involved in the actual collecting of the specimens.

The species most abundantly represented in the collection is Pallas's murre. It is obviously the most important single bird species to the Eskimo, and it is obvious from the enormous number of bones, that the species was as abundant in the past as it is in the present.

The other birds commonly used for food include the crested and the paroquet auklets, the Pacific and king eiders, and, strangely enough, the pelagic cormorant. One of the surprises was the paucity of goose bones, especially of the emperor goose. Pigeon guillemot, oldsquaw, long-tailed jaeger, red-faced cormorant, and short-tailed albatross come next in descending order of frequency, and after them come a large number of species, present in varying quantities.

The village sites involved in this study have been described by Collins (Geogr. Review **22**: 109–114. 1932.) from whose account the following remarks are extracted.

On the gravel spit near the present village of Gambell, at the northwest end of the island, are three abandoned villages, known to the Eskimos as Miyowaghameet, Ievoghiyogameet, and Seklowaghyaget, while a recently abandoned village immediately adjoins the present settlement of Gambell. The gravel spit extends westward from Gambell Mountain, on the slopes of which is the oldest village site, the one referred to in this paper as Hillside Village.

At the opposite, southeast, end of the island is the old village site of Kialegak, judged to be of approximately the same age as Ievoghiyogameet. The estimate of the age of the sites is, of course, very vague but in the case of the four villages near Gambell, it was possible for Collins to work out a relative, chronological sequence, even if the absolute age was indeterminable. To quote him on this point:

> Beginning at the base of the mountain and extending westward to the village at the end of the spit is a series of parallel ridges of gravel—old beach lines—which from the top of the mountain can be seen very distinctly. The position of the several old villages in relation to these former beach lines and to the present beach affords some evidence of their respective antiquity, for villages of the maritime Eskimo are always situated close by the sea or other body of water. The ruins closest to the present village at the end of the spit should be the latest; these are the recently abandoned houses . . . and the adjoining old site Seklowaghyaget. . . . In the same way the oldest of the abandoned villages should be Miyowaghameet . . . three-fourths of a mile away at the base of the mountain and half a mile distant from the sea and enclosed in the first two (the oldest) beach lines. Ievoghiyogameet . . . , some 200 yards north . . . (of Miyowaghameet), is separated from it by four beach lines and thus should date from a somewhat later period. Between . . . (it) . . . and the north shore are six more old beach lines, most of which were no doubt piled up after the abandonment of the village.
>
> The archeological evidence resulting from four months of intensive excavation bore out this assumed sequence. . . . A fifth site . . . (Hillside Village) . . . , unknown to the Eskimos and completely covered over with sod, moss, and rocks, was found on the lower slope of the mountain. . . .

To sum up for our immediate purposes, the oldest site is Hillside Village, estimated as possibly 2500 or more years old; next is Miyowaghameet, assumed to be about 2000 years old; then Ievoghiyogameet, around 1000 years old; Kialegak corresponds in age with Miyowaghameet and Ievoghiyogameet, chiefly with the latter; Seklowaghyaget is estimated to have been occupied up to about 200 years ago, and the recent Gambell site is supposed (on hearsay evidence from the natives, as well as from the nature of the excavated materi-

als) to have been abandoned about 40 years ago. The lower strata of its middens may be 100 years older.

In the course of his work Collins made a great many cuttings or diggings in each of these sites and recorded the levels of each. Of these individual diggings about 75 revealed bird bones. The time element in each site between superficial and basal strata is, however, too short to be of significance as far as the ornithological results are concerned, however much it may mean to the anthropologist, and in this paper I have combined many of these individual data.

I am greatly indebted to Mr. Collins for much information regarding the location and relative age of the sites, and for his patience in answering many questions more or less relevant to the immediate topic at hand.

The specimens of bones are all in the United States National Museum.

Family GAVIIDAE Loons

Gavia adamsi (Gray) Yellow-billed Loon

The yellow-billed loon is represented only in the diggings of sites about 1000–2000 years old; thus the northern and western sections of Miyowaghameet yielded a fragmentary sternum, radius, and metacarpal; Ievoghiyogameet a fragmentary sternum; while the Kialegak site at the opposite end of the island produced a tarsometatarsus and a metacarpal of this bird.

Judging by the size of the bones of this species, which would make for both their preservation and discovery, the few bones found and the few diggings containing them seem to indicate that either the bird was always scarce or hard to get or not sought after by the Eskimos.

Gavia arctica pacifica (Lawrence) Pacific Loon

The Pacific loon appears first in the Ievoghiyogameet site where it is represented by a broken sternum. The Kialegak ruins yielded a single tibiotarsus attributable to this species. In the recent site at Gambell a part of a skull and a broken sternum were found. All in all, the story is similar to that of the yellow-billed loon, a scarcity of remains of the species due to the same several possible factors.

Gavia stellata (Pontoppidan) Red-throated Loon

The diggings at Ievoghiyogameet and at Miyowaghameet, disclosed several bones of the red-throated loon. Ievoghiyogameet revealed this species in three separate cuttings representing the whole

time duration of the village deposit, from the surface layer to the basal portion, the bones (single ones in all cases) being a sternum, a tibiotarsus, and a metacarpal. At Miyowaghameet, in the relatively younger northwest deposits an ulna was found. In the much more recent deposits at Seklowaghyaget a tibiotarsus was unearthed.

Family DIOMEDEIDAE Albatrosses

DIOMEDEA ALBATRUS Pallas Short-tailed Albatross

In my paper on the birds of St. Lawrence Island (Proc. U. S. Nat. Mus., **80**, art. 12: 8. 1932.) I wrote that although Nelson and Turner saw this albatross at sea near and about St. Lawrence Island, the only definite records for the island are two mandibles found there by Nelson and a maxilla dug up by Collins at Miyowaghameet. A study of the present collection of bones has revealed this species in no less than ten separate cuttings ranging from the most recent sites to the most ancient one—the extent of time between the two extremes being around 2500 years or more. Beginning with the oldest, we may mention them in chronological sequence: Hillside Village, fragments of humeri, ulnae, and metacarpals; Miyowaghameet, 4 separate diggings, a total of one pair of maxillae, 1 pair of clavicles, 1 fragmentary ulna, 1 fragment of a mandible, 1 tarsometatarsus; Ievoghiyogameet, 2 cuttings, 1 fragmentary pair of clavicles, 1 tarsometatarsus, 3 metacarpals; Seklowaghyaget, 1 tibiotarsus; Gambell (recent) 2 cuttings, 1 humerus, 1 pair maxillae, 1 ulna, 1 radius.

Apparently the short-tailed albatross was used for food whenever it could be obtained. The large size of its bones makes it probable that relatively fewer were overlooked by the collector than in the case of smaller bird bones.

Family PROCELLARIIDAE Shearwaters, Fulmars

PUFFINUS TENUIROSTRIS (Temminck) Slender-billed Shearwater

This species has not been recorded previously from St. Lawrence Island. It is represented by a coracoid in perfect condition, found at Miyowaghameet.

FULMARUS GLACIALIS RODGERSI Cassin Rodger's Fulmar

Bones of this fulmar are noticeably scarce in the present collection, only two being definitely attributable to the species. At Ievoghiyogameet a coracoid was unearthed, and at Kialegak a tibiotarsus was

found. The fulmars, being very pelagic in their habits are probably seldom killed by the Eskimos, a fact that may help to explain the absence of further osseous remains.

Family PHALACROCORACIDAE Cormorants

PHALACROCORAX PELAGICUS PELAGICUS Pallas Pelagic Cormorant

The pelagic cormorant is represented in 17 individual diggings, from the most ancient to the most recent. It was most abundantly found in the deposits at Kialegak, where it was unearthed in 6 separate cuttings, and at Ievoghiyogameet, where it was revealed in five cuttings; 2 diggings at Miyowaghameet turned up bones of this cormorant as did also 2 cuttings at Seklowaghyaget; the ancient hillside village near Gambell and the recent village at Gambell each revealed one bone of this bird. Although in most of the 17 diggings only single bones or only a very few were found, in the upper layers at Ievoghiyogameet no less than 16 tarsometatarsi were unearthed. This extraordinary abundance makes one wonder what unusual conditions may have made the birds so accessible or sought after at that time.

It is noteworthy that although many limb bones were found, only 4 synsacra and 1 sternum were unearthed, and no parts of the skull or mandibles.

PHALACROCORAX URILE (Gmelin) Red-faced Cormorant

Hitherto this cormorant has been known from St. Lawrence Island only on the basis of Nelson's statement that it is a, " . . . more or less common summer resident" there. No specimens have been taken in the flesh as far as I know. However, bones attributable to this species are included in the results of 8 diggings, but only in cuttings of ancient sites. It may well be that the species was formerly more abundant on St. Lawrence Island that it is today, but no reasons can be advanced to account for its change in status. The most ancient site, the Hillside Village revealed a fragment of a humerus; Ievoghiyogameet yielded the greatest number of bones distributed among 4 cuttings, one of which contained as many as 12 tarsometatarsi and 3 tibiotarsi; while 3 cuttings at Kialegak produced 2 humeri and 1 tarsometatarsus. The fact that the species is represented at both ends of the island (Gambell and Kialegak) indicates that it was widespread in its local range. If it were present in only one place, it might have been assumed that its hypothecated decrease might have been due to the decimation of the sole colony on the island.

Family ANATIDAE Ducks, Geese, Swans

Cygnus columbianus (Ord) Whistling Swan

When one considers the gastronomic desirability of this, the largest edible bird on the island, and its fairly even distribution there, it is surprising that its remains have been found only in the deposits at Kialegak and not in any of the old sites near Gambell. At Kialegak it is represented by a pair of clavicles and several fragmentary bones found in 3 separate diggings.

Branta canadensis minima Ridgway Cackling Goose

The cackling goose is an addition to the known avifauna of St. Lawrence Island. It is represented in 2 cuttings of the upper layer of the Kialegak site; in one by a coracoid, in the other by a pair of clavicles.

Branta nigricans (Lawrence) Black Brant

This goose is also new to the known bird fauna of the island. It is represented by a metacarpal found in a basal digging at Kialegak.

Philacte canagica (Sevastianoff) Emperor Goose

The remains of the emperor goose are remarkably few in number considering the abundance of the bird on St. Lawrence Island, and the extent to which it is hunted and used for food by the Eskimos. Furthermore, its bones are present in neither the two oldest sites (Hillside Village and Miyowaghameet) nor the most recent one (Gambell), but chiefly in the diggings at Kialegak, and, in small numbers, in 2 cuttings at Seklowaghyaget. At Kialegak bones of the emperor goose were found in 5 cuttings; at Seklowaghyaget in 2 diggings. Strangely enough, almost no long bones were unearthed, but chiefly metacarpals and fragments of clavicles and coracoids.

The fact that the majority of the bones come from Kialegak at the southeast end of the island is in keeping with the present distribution of the bird. It is found chiefly in the southern part of the island, especially in the vicinity of the long lake and lagoons. On the north side the species is not nearly so common.

Anser albifrons albifrons (Scopoli) White-fronted Goose

The white-fronted goose is represented in the remains from Kialegak (2 diggings) and Ievoghiyogameet (1 cutting), in all cases by metacarpals only. It is peculiar, to say the least, that all four species

of geese are represented by bones other than the long limb bones usually preserved, such as the humerus, femur and tibiotarsus.

Apparently the white-fronted goose has always been an uncommon bird in St. Lawrence Island, as it is today.

DAFILA ACUTA TZITZIHOA (Vieillot) American Pintail

The pintail is represented by a single bone, a tarsometatarsus found at Kialegak.

NYROCA MARILA (Linnaeus) Greater Scaup Duck

One sternum, collected at Ievoghiyogameet, is referable to this duck. Previously the greater scaup duck was known from St. Lawrence Island only on the basis of Nelson's statement of its occurrence there. No specimens were collected by him.

CLANGULA HYEMALIS (Linnaeus) Old-squaw

The old squaw is one of the commonest ducks on the island, and its bones have been found in 12 diggings, the greatest number being at Kialegak, where it is represented in 7 cuttings. The oldest bones come from Miyowaghameet (3 diggings); one fragmentary skull was found at Ievoghiyogameet, and a piece of a sternum was unearthed in the recent village site at Gambell.

HISTRIONICUS HISTRIONICUS PACIFICUS Brooks

Western Harlequin Duck

The western harlequin duck is represented by bones chiefly in the Kialegak and Ievoghiyogameet sites. In the former it was found in 4 diggings; in the latter village, in 2 cuttings. A single coracoid comes from the excavations at Seklowaghyaget as well. The Kialegak and Ievoghiyogameet specimens are all humeri except for a pair of tarsometatarsi.

POLYSTICTA STELLERI (Pallas) Steller's Eider

Steller's eider appears among the remains of the oldest site, the Hillside Village, in the form of a fragmentary femur. Otherwise it is represented only from Kialegak, where, however, it figures in four diggings, 3 of which yielded a humerus apiece and 1 a synsacrum.

SOMATERIA V-NIGRA Gray Pacific Eider

The Pacific eider is abundantly represented in the present collection, its bones being recorded from 32 separate cuttings, ranging

throughout all the sites and ages except the very oldest (Hillside Village), and Seklowaghyaget. At Miyowaghameet, it was found in 3 cuttings; at Ievoghiyogameet, in 7 cuttings; at Kialegak, in 20 diggings; at the recent Gambell site, in 2 diggings.

SOMATERIA SPECTABILIS (Linnaeus) King Eider

Today the Pacific eider is much more abundant on St. Lawrence Island than the king eider, but, if we may judge by the skeletal remains, the latter species was somewhat the commoner of the two in the pre-historic past, or else was often selected as an object of the chase by the Eskimos. Remains of the king eider are included in the material excavated at 37 different diggings. The oldest village site revealed a coracoid of this duck, and its bones have been found at each of the other village deposits except, strangely enough, the recent village site at Gambell. At Miyowaghameet it was found in 1 cutting; at Ievoghiyogameet in 3 cuttings; at Kialegak, where it was found in greatest numbers, in 31 diggings; at Seklowaghyaget in 1 digging. The absence of this species from the recent Gambell site is of interest in connection with its relative decrease in abundance at present.

ARCTONETTA FISCHERI (Brandt) Spectacled Eider

The spectacled eider is represented only in the collections from Kialegak, where it was found in 4 cuttings. All in all, 3 humeri and 4 coracoids were unearthed.

MELANITTA DEGLANDI (Bonaparte) White-winged Scoter

The discovery that this duck was represented in no less than 9 diggings at Kialegak is very surprising in view of the fact that the species had never been recorded from the island before. To find a bird new to the local avifauna in a single cutting is a thing to be expected, but to find such abundant evidence of one is really unusual. It is significant that the species was found only from the southeast end of St. Lawrence Island, the point nearest its mainland range. The bones include 2 tarsometatarsi, 2 tibiotarsi, 1 coracoid, and many fragmentary pieces.

MELANITTA PERSPICILLATA (Linnaeus) Surf Scoter

A humerus, found at Kialegak, is of this species. The surf scoter is new to the avifauna of St. Lawrence Island. As far as I know, this is the most northwestern locality whence the species has been recorded as yet.

Oidemia americana Swainson American Scoter

The American scoter seems (from somewhat inconclusive evidence) to have been commoner on St. Lawrence Island in the past than it is today. Bones of this duck are present in the collections made in 5 different diggings at Kialegak. Of naturalists who have made observations on the bird life of the island, only Nelson has recorded this species, and he reported it as occurring only sparingly there. None of the collectors since the time of Nelson's visit have found it.

The fact that no bones of this duck were found at any of the sites at the northwest end of island suggests that even in the past (perhaps 1000 years ago) its range on the island was very limited. This may still be so, and may be the reason recent visitors have failed to find it.

Mergus merganser subsp. indet. Merganser

A number of bones, from 5 different diggings at Kialegak, are definitely referable to this species, but I cannot find any diagnostic skeletal characters by which to determine their subspecific identity. Neither race of the merganser has ever been found near St. Lawrence Island and either one might be the form involved as the island is just about half way between the known limits of their respective ranges. If the bird should turn out to be the nominate Eurasian form, it would be an addition to the North American avifauna, if it should be *M. m. americanus*, it would be a considerable extension of range. The species is new to St. Lawrence Island.

The bones include 1 humerus, 1 radius, 2 ulnae, 7 metacarpals, and 1 tibiotarsus.

Mergus serrator Linnaeus Red-breasted Merganser

The red-breasted merganser is represented by a tibiotarsus and a metacarpal, both from Kialegak (2 separate diggings).

Family GRUIDAE Cranes

Grus canadensis canadensis (Linnaeus) Little Brown Crane

Three village sites (Miyowaghameet, Ievoghiyogameet, and Kialegak) yielded bones of this crane. Most of the bones are fragmentary but a whole tarsometatarsus was found at Ievoghiyogameet. In a bird of this size the absence of records from a deposit is fairly good evidence that the species was either not present or was not fed upon by the Eskimos.

Family SCOLOPACIDAE Woodcock, Snipe, and Sandpipers

Heteroscelus incanus (Gmelin) Wandering Tattler

A humerus found in one of the basal diggings at Kialegak appears to be of this species. St. Lawrence Island is the northwesternmost locality from which this bird has been recorded so far. The wandering tattler is an addition to the avifauna of the island.

Family STERCORARIIDAE Jaegers and Skuas

Stercorarius pomarinus (Temminck) Pomarine Jaeger

The pomarine jaeger is represented only in the material excavated at Kialegak, where its bones were found in 4 separate diggings.

Stercorarius parasiticus (Linnaeus) Parasitic Jaeger

The three oldest village sites (Hillside Village, Miyowaghameet, and Kialegak) yielded osseous remnants of the parasitic jaeger, but the more recent sites did not. Only a few bones were found in all—3 humeri, 3 tibiotarsi, 1 ulna, and several fragments.

Stercorarius longicaudus Vieillot Long-tailed Jaeger

The abundance of bones of this jaeger came as a distinct surprise as the species was not previously recorded as particularly common on St. Lawrence Island. Bones attributable to it were found in twenty-six diggings, from the oldest site (Hillside Village) to the newest (the recent Gambell site). In the Hillside Village site a fragmentary humerus and a tarsometatarsus were found; at Miyowaghameet (4 cuttings) 7 humeri, 4 tarsometatarsi, and 3 tibiotarsi were found; at Kialegak bones were found in 15 separate cuttings, the bones including 7 humeri, 1 coracoid, 6 tarsometatarsi, 2 femurs, and fragments; at Ievoghiyogameet (5 diggings) 8 humeri, and 4 tarsometatarsi were collected; at Gambell (recent) 2 tarsometatarsi were unearthed.

This bird is said to walk about on the ground when feeding on insects, and it is probably at such times that the Eskimos are able to kill it in numbers.

Family LARIDAE Gulls, Terns

Larus hyperboreus Gunnerusm Glaucous Gull

The ancient Hillside Village yielded a fragmentary humerus and a piece of a mandible of this gull; a coracoid was found at Miyowaghameet; 2 cuttings at Ievoghiyogameet produced 1 skull, 1 extra max-

illa, 1 tarsometatarsus, and 1 coracoid; the Kialegak collection contained a pair of mandibles.

LARUS GLAUCESCENS Naumann Glaucous-winged Gull

This gull is more abundantly represented in the collection than the preceding species. It was found in 7 diggings at Miyowaghameet, Ievoghiyogameet, Kialegak, and the recent site at Gambell. The remains include 4 metacarpals, 1 fragmentary skull, 1 pair of mandibles, 1 sternum, 1 ulna, and fragments.

LARUS BRACHYRHYNCHUS Richardson Short-billed Gull

This gull was not mentioned in my list of the birds of St. Lawrence Island (Proc. U. S. Nat. Mus. **80,** art. 12. 1932), but I have since found that Bent (Bull. U. S. Nat. Mus. **113**: 145. 1921.) states that it breeds on the island. Furthermore, the map in Cooke's paper on the distribution of North American gulls (U. S. Dept. Agric. Bull. **292**: 47. 1915.) shows a record for St. Lawrence Island. Bones of this gull were found in 3 diggings, all at Ievoghiyogameet. The bones include 3 ulnae and a sternum.

RISSA TRIDACTYLA POLLICARIS Ridgway Pacific Kittiwake

This gull is represented in 11 diggings in the old village sites (Hillside Village, Miyowaghameet, Kialegak, and Ievoghiyogameet) and seems to have been as numerous 1000 or more years ago as it is today. A broken pair of mandibles found at Hillside Village and an ulna from Miyowaghameet are the oldest specimens in the order named. Kialegak site contained many bones, as 4 cuttings there revealed this species; but the greatest abundance of kittiwake bones was found at Ievoghiyogameet, where 5 cuttings yielded 1 sternum, 1 pair of mandibles, 1 skull, 6 ulnae, 1 humerus, and 1 metacarpal.

RISSA BREVIROSTRIS (Bruch) Red-legged Kittiwake

This gull is an addition to the avifauna of St. Lawrence Island. It is represented by a pair of mandibles found in a superficial digging at Ievoghiyogameet. This constitutes a considerable northward extension of the known range of the species.

Family ALCIDAE Auks, Murres, Auklets

URIA LOMVIA ARRA (Pallas) Pallas's Murre

This, the most abundant bird on St. Lawrence Island today, is also by an enormous percentage, the species most abundantly represented

by the bones from the old village sites. It is represented in 69 diggings, from all the sites and of all the ages. It is also represented by almost as many individual bones as all the other species combined. Two humeri, collected at Kialegak, match exactly humeri of *Uria aalge californica*, but I am not convinced that it is advisable to attempt to separate the two murres on the basis of their humeri as they are so very similar and overlap in their dimensions.

It is obvious that Pallas's murre is the most important avian item of food in the lives of the St. Lawrence Eskimos.

Cepphus columba Pallas Pigeon Guillemot

This guillemot is represented by bones from 16 diggings from all the village sites except Seklowaghyaget. Apparently its numerical status on St. Lawrence Island has not changed much during the last 2500 or so years.

Brachyrhamphus brevirostris (Vigors) Kittlitz's Murrelet

A humerus from a basal digging at Ievoghiyogameet is the only record of this murrelet for St. Lawrence Island. Although it is known to breed on both the Alaskan and Siberian coasts of Bering Sea and adjacent parts of the Arctic Ocean, it had not been reported from St. Lawrence Island before.

Cyclorrhynchus psittacula (Pallas) Paroquet Auklet

The paroquet auklet is abundantly represented in the diggings of all the village sites except the very old Hillside Village. The greatest quantity of bones came from Kialegak in the southeastern part of the island; fewer from the Gambell region at the northwestern tip. This is in keeping with present local distribution of this bird on St. Lawrence Island.

Aethia cristatella (Pallas) Crested Auklet

The crested auklet, one of the common birds of St. Lawrence Island, is represented in 16 diggings, all from the sites at the northwest end of the island, and not at all from Kialegak at the opposite end, where it is replaced by the paroquet auklet, just as the two species complement each other's local range today. The old Hillside Village yielded 4 humeri; Miyowaghameet (4 cuttings) many bones; Ievoghiyogameet (6 cuttings) yielded still more, as many as 20 humeri, and 1 sternum being found in one digging alone; Seklowaghyaget (2 cuttings) produced several bones; and the recent Gambell site (2 dig-

gings) revealed many more, as many as 11 humeri and 3 sterna in one digging.

AETHIA PUSILLA (Pallas) Least Auklet

The least auklet is represented in 3 diggings from 3 villages at Gambell (Miyowaghameet, Ievoghiyogameet, and the recent Gambell site). Only a few bones were found in all, the total being 4 humeri and 1 sternum.

FRATERCULA CORNICULATA (Naumann) Horned Puffin

In spite of their abundance and size neither of the puffins inhabiting St. Lawrence Island seems to have figured very largely in the diet of the ancient Eskimos. Remains of the present species were found in 8 diggings representing the following sites: Miyowaghameet, Kialegak, and Ievoghiyogameet. Most of the bones were found singly; in 2 diggings more than 1 bone was found (2 in one case, 3 in the other).

LUNDA CIRRHATA (Pallas) Tufted Puffin

This puffin is more numerously represented than the horned species. It figures in 14 diggings from both ends of the island (Gambell and Kialegak). The specimens come from ends of the chronological series of excavations—from Hillside Village, Miyowaghameet, Ievoghiyogameet, Kialegak, as well as from the recent Gambell site.

Family STRIGIDAE Owls

NYCTEA NYCTEA (Linnaeus) Snowy Owl

The snowy owl is represented by a pair of metacarpals and by a few fragments, both from cuttings at Kialegak. The absence of bones of this species from the other sites and from the other diggings at Kialegak may mean that owls are not looked upon as a food supply as long as other birds are available.

ETHNOLOGY.—*Newly discovered Powhatan bird names.*[1]

JOHN R. SWANTON, Bureau of American Ethnology.

Dr. Alexander Wetmore, assistant secretary of the Smithsonian Institution, has called my attention to an article in *The Auk* for July, 1933 which contains a number of bird names in Indian not apparently recorded elsewhere. The article is entitled *Topsell's 'Fowles of heauen'* and was read by its author, Bayard H. Christy, at the fiftieth meeting of the American Ornithologists' Union, Quebec, October 18, 1932.

[1] Received October 30, 1933.

Edward Topsell, it seems, who died about 1638, was "an English clergyman, and sometime curate of St. Botolph, Aldersgate," chiefly remembered as the author of a *Historie of four-footed beastes* and a *Historie of serpents*, which were printed in 1607 and 1608 respectively. "It now appears," says Christy, "that, having projected a third work on *The fowles of heauen*, he progressed with it so far as to complete a first part—perhaps one fifth of the contemplated whole. The dedication is to Baron Ellesmere, the Lord Chancellor; to him, as may be supposed, the MS. was transmitted; and from a descendant of his the Huntington Library acquired it. Resting today in the archives of that library, it forms part of the Ellesmere Collection, and bears the identifying number, E L 1142." From internal evidence it appears that it was written "before the end of the year 1614, and perhaps a year or two earlier than that."

Among the birds illustrated are nine from Virginia, eight of which, all but *The Crane of Virginia*, are accompanied by their Indian names which Christy gives and attempts to identify as follows:

"The *Aushouetta* (= the Thrasher?)
The *Aupseo* (= the Bluebird)
The *Aiussaco* (= the Flicker)
The *Artamokes* (= the Blue Jay)
The *Chuguareo* (= the Red-winged Blackbird)
The *Chuwheeo* (= the Towhee)
The *Chowankus* (= the female Towhee?)
The *Tarawkow Konekautes* (= the Sandhill Crane)

"A *Black-macke of Brasilia* is also figured which manifestly is a tanager."

At the end of the volume is a prospectus indicating the birds which were to be treated in subsequent parts, and among these are eight more Virginia birds, all but one of which, the *Turkey Cocke*, have their Indian designations. These are the "*Kaiuk*, *Manasscneau*, *Meessenouns*, *Pockway*, *Poocgueo*, *Poppogattuweo*, and *Teauh*."

While the term "Virginia" had a somewhat extended use in Topsell's time, its appearance and the date of compilation of the manuscript show conclusively that we must look to the Powhatan language for the origin of the names. This is important because it means the addition of fourteen or fifteen words to our scanty material from this Algonquian dialect. Not being a student of Algonquian myself, I have submitted these words to two fellow members of the Bureau of Ethnology, Mr. J. N. B. Hewitt and Dr. Truman Michelson, to

Prof. Frank G. Speck of the University of Pennsylvania, and Prof. John M. Cooper of the Catholic University of America, who have kindly furnished the following notes:

Aushouetta. Attention might be called to a bird called *ahshowcutters,* mentioned by Strachey, which had "carnation-coloured wings." Speck says this is perhaps the red-start, the term being derived from the word for "fire" (cf. Penobscot *skunt·e's,* "little fire," or "little flame"), from its red flashing wings and tail, pointing out that in Cuba it is known as the *candelita* for the same reason. Commenting on this, Cooper states that the Tête-de-Boule Cree word for "fire" is *ickwudē.*[2]

Aupseo. Speck points out that this name is evidently identical with Oklahoma Delaware *a'psi·o* which signifies "he is white," white and light blue being covered by the same term.

Aiussaco. The Tête-de-Boule Cree term obtained for this bird by Cooper *wuràkōnē'o,* is evidently unrelated, but that for crow, *āyā'sio* is rather close. The common Cree word for raven, and often for crow, he gives, however, as *kā'kāgō.*

Artamokes. None of the informants could suggest a parallel.

Chuguareo. Hewitt gives the following names for this bird: *chógan* in Narragansett (Williams), *tsougheres* in Abnaki (Rasle), *chog-luskw* in modern Abnaki (K.A.), *tschoquali* or *tschukqualli* in Delaware (Zeisberger), *tskennak* in modern Delaware (Anthony), *assiggenauk* (*siggenauk*) (Tanner), *auchugyeze* in Pequot (Stiles). Speck gives the Penobscot word as *tcugwalα'so* and states that it is derived from the bird's call as are also the Delaware terms. Cooper says that the Tête-de-Boule Cree name is *mi'kwo tcatca'kʷerȯ,* in which *mi'kwo* signifies "blood," and *tcatcak* is onomatopoetic. "The Tête-de-Boule children, when they hear or see a redwinged blackbird, imitate its call by a half-chanted articulated verbalization, as follows: *tcȧk' tcȧk' tcȧk' tcȧkᵃ-lȧwē',* the last *ē* being very long."

Chuwheeo. Cooper reports having once recorded the Tête-de-Boule Cree word for this bird as *pastē'cīc,* but feels none too sure of it and in any case there is evidently no relationship.

Chowankus. No suggestion was ventured. The form of this word is rather similar to Strachey's *cheawanta,* "a robin red-breast," but that may be merely accidental.

[2] In the notes furnished by Dr. Cooper, c is equivalent to English sh; ȧ to English u in but; ' indicates a glottal stop; and ʷ is a voiceless or barely audible sound. Prof. Speck has the following special signs: i· a closed vowel like ee in queen; n· and t· lengthened consonants equivalent to nn and tt; α an obscure vowel like e in English her; ʻ an aspiration following a vowel or consonant.

Tarawkow Konekautes. Hewitt gives the following synonyms: *tare'gañ* (pl. *tare'gok*) in Abnaki (Rasle), *taroecka* in the Algonquian dialect of New Sweden, *tale'ka* in Delaware (Zeisberger), *taûnek* in Narragansett (Williams). He thinks "konekautes" signifies "long legged," and is supported by Speck who gives the Delaware form of the word as *kwun·i·ka't.*

Kaiuk. Hewitt gives *kaa'kow* or *kaiakou* in Abnaki (Rasle), and points out that the same word is given by Strachey in the form *coiahqwus.* Cooper states that the Tête-de-Boule Cree term for the American herring gull is *kio'k*^{wa}, and that the Albany Cree on James Bay call this bird *kīack,* the common tern being *kīa'ck*^{w}*ōcīc.*

Manasscneau. Cooper gives *uki'skimanisē'o,* kingfisher, the Tête-de-Boule Cree term, as involving a possible explanation.

Meessenouns. Michelson says that this word seems to signify "little big-partridge," perhaps indicating a small specimen of some bird known as "big-partridge." Dr. Wetmore suggests that it was probably the quail.

Pockaway and *Poocgueo.* Michelson thinks that one, and perhaps both, of these names were intended for the pheasant. Cooper suggests, rather doubtfully, that *pockaway* may be related to Tête-de-Boule Cree *pīck,* "night-hawk," and cites *pĕpŭckē'o* (given by another informant as *pàpàskio*) as the name of the ruffed grouse in the same language. Dr. Wetmore thinks that the bird intended by these two names was the ruffed grouse, or possibly the prairie chicken.

Poppogattuweo. According to Michelson this word seems to indicate some bird making a noise as it alights. Speck says it may possibly refer to the quail, the Mohegan-Pequot word for which would be *bopu'kwati·s,* "the spotted or speckled little (bird)." Cooper mentions as a possible analogy Tête-de-Boule Cree *papastē'o,* the name of one of the woodpeckers.

ARCHEOLOGY.—*A variety of Caddo pottery from Louisiana.*[1] W. M. Walker, Bureau of American Ethnology. (Communicated by John R. Swanton.)

The accidental discovery of an ancient burial ground near the town of Natchitoches, La. during the summer of 1931, reported by the writer in the Smithsonian Explorations volume for that year, has made possible the identification of the type of pottery made by the Natchi-

[1] Published by permission of the Secretary of the Smithsonian Institution. Received December 8, 1933.

toches, one of the constituent members of the Caddo confederacy. This identification rests not alone on the finding of European trade objects in immediate association with the Indian artifacts but is further strengthened by documentary evidence tending to show that the site stands on or near the village of the Natchitoches first visited by Henri de Tonti in 1690. As the detailed proof of this assertion has

Fig. 1—Polished and engraved bowl, black with red filled lines. Typical Natchitoches pottery. $\times\frac{1}{2}$.

been offered in the complete report already submitted to the Bureau, no attempt will be made to repeat it, even at the risk of appearing dogmatic.

The principal significance of this discovery is that it establishes not only the pottery type of this particular tribe but also shows it to be practically identical with that of a closely allied tribe, the Ouachita. Thus we have a key which it is hoped will help unlock the major problem confronting the archeologist in the Red River region—the ancient remains attributable to the Caddo tribes. The published reports of such workers as Moore,[2] Harrington,[3] and Pearce,[4] with their

[2] Moore, C. B. *Antiquities of the Ouachita Valley.* Jour. of the Acad. Nat. Sci. Phila. **14**: 1. 1909.

[3] Harrington, M. R. *Certain Caddo sites in Arkansas.* Indian notes and monographs, Mus. Amer. Ind. Heye Foundation. N. Y. 1920.

[4] Pearce, J. E. *The archaeology of east Texas.* Amer. Anthrop. **34**: 4. 1932.

many excellent illustrations, have laid the ground work for detailed comparative studies which will be rendered easier after further determination of the other archeological components of historic Caddo cul-

Fig. 2.—Bottle fragment, Natchitoches type, incised but not polished. $\times \frac{1}{2}$.

ture, such as those furnished by the Adai, Yatasi, Petit Caddo, and Grand Caddo.

Unfortunately of the pottery vessels found at the Cane River site near Natchitoches practically none were recovered intact, but enough fragments were obtained to give a good idea of the nature of the ware and its decoration. In form they range from conical bowls, cup-like bowls with flaring collars, small jugs and pots, to subglobular bottles

with short necks. The quality of the ware also varies from coarse, crude, undecorated poorly fired pieces to highly polished, engraved specimens rubbed with ochraeous coloring matter—the typical Red River Ware of Moore and Harrington. The bowl fragment seen in fig. 1 is of this latter type, bearing traces of red paint only in the engraved portions of the collar, while its companion from the same burial, fig. 2, bears only an incised decoration much more crudely executed and lacks the final polish of the bowl. All of the ware is heavily shell-tempered, whether decorated or not. This is in sharp contrast to the condition reported by Harrington for the Caddo pottery described by him from southwestern Arkansas, but may perhaps be due to greater abundance or availability of the mussel-shell material at the Natchitoches site nearer the mouth of Red River. The paste is grayish in color, but turns reddish after firing.

Decoration of the Natchitoches pottery was produced apparently only by the incising and engraving techniques, as no sherds bearing cord markings, punctate, stamped, ridged, or rouletted designs were present, nor was there any use of paint other than in the color-filled engravings already noted. The designs most typically found are made up of combinations of parallel straight and curved lines, interlocked scroll meanders, and rounded spots, with reticulated or hachured spaces intervening. Decoration applied after drying and firing may be best described as incised, that completed after polishing, as engraved. The shiny black polish on the bowl may have been achieved after dipping the vessel in bears' oil after firing, a process recorded by Bushnell for the Choctaw.[5] Elements most commonly found in the bowl designs comprise four spiral arms appearing to radiate from a circle on the under side of the vessel which is always left as a cleared space free from any decoration. In the case of the small cup-like bowls a different band of design forms the encircling collar of the vessel, generally employing a zig-zag motif with large spots. One bowl found had five instead of the customary four spiral arms radiating outward from the central circular area on the bottom over the body of the vessel.

Small pipe bowls not over two inches high were also manufactured out of the same kind of shell-tempered clay (Fig. 3). They are in the form of a cone set into a cup-shaped base and lack an attached stem, thus differing completely from the forms found by both Moore and Harrington farther up Red River.

[5] Bushnell, D. I. Jr. *The Choctaw of Bayou Lacomb, Louisiana.* Bur. Amer. Ethnol. Bull. **48**: 12. 1909

The closest resemblance to the Natchitoches pottery is that found by Moore on the Ouachita river at Glendora Plantation and Keno Place. Both in shape and decoration these vessels are almost duplicates of those found at Natchitoches, the explanation of which is that the Ouachita and Natchitoches were found living together at the site visited by Tonti on Red River, and the trading path between the distant settlements of the two tribes is clearly shown on La Fon's map of Louisiana as late as 1806. Which tribe is to be regarded as the originator of this ceramic style is not certain from the data at hand.

Fig. 3.—Natchitoches pottery pipe bowl. Note possible property mark scratched on front. ×1.

The northernmost limit of distribution of this kind of pottery seems to be along the Arkansas river in the vicinity of Pine Bluff, Arkansas. Moore found at the Douglas site and at the site near Greer unmistakable specimens of Natchitoches-Ouachita ware and it was present also at the Battle Place site on Red River. More recently Pearce has described and figured the same kind of pottery from farther west in the Red River section of East Texas[6] which may also be Natchitoches in origin as the early historians note an upper and a lower village of this tribe some 100 leagues apart on Red River. It is important to note, however, that this ware differs somewhat from that found by Harrington in southwest Arkansas and regarded by him as of Caddo manufacture. Although the technique of decoration

[6] Pearce op. cit. Plate 23 a.b.

is much the same there are stylistic differences that are quite noticeable. The scroll, for instance, is not so prevalent a motif as in the Natchitoches ware. The characteristic vessel forms of the latter are also absent, though there is present a greater variety of shapes. This is not to be taken as an indication that Harrington's pottery may not also be Caddo, but only that it does not conform to the ceramic pattern here identified as belonging to the Natchitoches-Ouachita division of the Caddo confederacy. When the village site of the Kadohadacho or Grand Caddo somewhere in the great bend region of Red River, can be located definitely and its archeological remains studied we may be in a position to see the relationship of these two types of pottery more clearly.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1056th MEETING

The 1056th meeting was held in the Cosmos Club Auditorium, May 20th, 1933, President O. S. Adams presiding.

Program: J. G. Thompson: *The use of physical methods for testing purity of metals.*—Some of the common metals such as aluminum and zinc have been produced recently in extremely pure forms, approaching absolute purity. The new and improved properties of these superpure metals have convinced metallurgists that amounts of impurities formerly considered to be unavoidable and not objectionable can no longer be so regarded; a few thousandths of one per cent are no longer negligible.

The Bureau of Standards is attempting to prepare iron as pure as possible in order that the basic properties of this fundamentally important metal may be determined. A state of purity has been attained such that the exact determination of the purity and of minor changes in the purity, in subsequent operations, has become a real problem. Chemical analysis is limited in its usefulness. The possible use of various physical methods has been considered, including spectrochemical analysis, the determination of thermal emf, permeability, and critical temperatures but it appears that none of these determinations yield the desired information. The most promising method for the determination of purity in high purity iron appears to be the determination of the temperature coefficient of resistivity but further information concerning the effect of details such as annealing treatment is needed. (*Author's abstract.*)

Discussed by Messrs. P. W. White, Roeser, Hawkesworth, Ramberg, Humphreys, Tuckerman, Kracek, and Rawdon.

Louis Jordan and H. S. Rawdon: *The preparation of metal single crystals and their utilization in metallurgical studies.*—The properties of metal single crystals are obviously the fundamental properties of the polycrystalline metals which are in very day use in scientific and engineering applications. These fundamental properties are modified in polycrystalline metals by the

effects of different crystal lattice orientations in adjacent grains and of grain boundary effects. It is logical to study such modifying effects by the preparation and examination of single crystal and bi-crystal metal specimens. One of the major problems of present day physical metallurgy is the study of the so-called "creep" of metals, that is, the slow and sometimes continuous plastic deformation of metals which are subjected to prolonged loading at temperatures which are relatively high as compared with the melting point of the metal in question. Creep tests of single crystal and bi-crystal metal specimens are promising much in this field of metallurgical study.

Metal single crystals may be quite readily formed either from the solid, the liquid, or the gaseous phase of a metal by several methods: (1) by straining and annealing a solid bar or strip of the metal; (2) by growing a metal "icicle" or "stalactite" by slowly raising a metal rod from the surface of a mass of liquid metal; (3) by slow deposition on a wire of atoms from metal vapor; (4) by lowering a crucible of liquid metal through a furnace; (5) by slowly cooling a stationary crucible of liquid metal so arranged that all cooling proceeds from one point on the crucible.

Metal single crystals exhibit several peculiarities in both physical and chemical properties. Indentations made on single crystals by conical or spherical indenting points produce patterns characteristic of the crystal lattice of the metal (square or hexagonal). Single crystal bars broken in tension deform to ribbon-like cross-section and break with a chisel-edge fracture instead of the familiar conical fractures of polycrystalline bars.

The chemical activity of different planes of atoms in the metal crystal lattice varies to such a degree that it is possible, by a suitable selection of etching reagents, to develop on the surface of single crystal specimens etched patterns characteristic of several simple lattice planes, e.g., the cubic, octahedral, or dodecahedral faces of the cubic lattice of copper. This furnishes a simple visual method of determining the crystal orientation in single crystal test specimens. (*Authors' abstract.*)

Discussed by Messrs. HAWKESWORTH, HUMPHREYS, H. L. CURTIS, and BRICKWEDDE.

1057TH MEETING

The 1057th meeting was held in the Cosmos Club Auditorium, October 14th, 1933, President O. S. ADAMS presiding.

Program: HARRY DIAMOND: *Recent developments in radio aids to air navigation.*—The paper discussed recent developments in directional guidance of aircraft by radio. Point to point guidance along the civil airways of the United States is provided by a network of radio range-beacons. Means have been developed for furnishing either aural, visual or combined aural and visual indication of the position of the airplane with respect to the beacon courses. A single transmitter and antenna system for simultaneous transmission of phone weather broadcasts and the beacon signals has also been developed. A recent major improvement in the beacon network is the replacement of the loop transmitting antennas by a new type of antenna system, called the TL antenna. The latter was developed to eliminate irregular and erratic course variations occurring at night.

A system of radio landing aids permitting safe landing of airplanes under zero conditions of ceiling and visibility was also described. The system comprises three elements; a low power radio range-beacon for giving guidance to the landing airplane along the proper approach to the airport, an ultra-high frequency landing beam for giving vertical guidance and marker beacons for

indicating the longitudinal position of the airplane. On the airplane a single crossed-pointer type instrument combines the indications from the first two elements, while the marker beacon signals are heard in the headphones. Successful tests of the system at College Park, Md. and Newark, N. J. were described and a movie reel of a completely blind landing was shown. (*Author's abstract.*)

Discussed by Messrs. HAWKESWORTH and WATSON DAVIS.

W. B. BURGESS: *Application of radio direction finding.*—After a brief history of the investigations of atmospheric disturbances, means were discussed for directional studies. It was shown that the cathode ray type of direction finder, first developed by R. A. Watson-Watt, has proven most practicable. Improvements in this type were traced from the first model, using twelve hundred foot loops, to one recently developed by the U. S. Navy, of unit construction, employing loops less than three feet square, but of high sensitivity.

This model gives instantaneous unilateral indications of direction and field strength on individual impulses. Two of these instruments are being used in a study of atmospherics due to tropical hurricanes. It is believed that their use will lead to an increase in the available data on such storms, and that losses due to them may be minimized by advance information of the storm path, as determined by the radio direction finder. (*Author's abstract.*)

Discussed by Mr. SEARLES.

The following informal communications were presented.

P. R. HEYL.—In 1863, Hermite proved that the number e, base of the natural system of logarithms, is transcendental. Lindemann in 1872 made use of this theorem to prove that e^z, where z is a rational number, is also transcendental. From this, Lindemann wrote, it follows that π is transcendental. The intermediate steps are not obvious. (*Secretary's abstract*).

Discussed by Messrs. HAWKESWORTH and NAIMAN.

P. R. HEYL.—The number π expanded to 708 terms contains the different digits as follows:

Digit	*Number of Occurrences*
0	75
1	76
2	74
3	73
4	71
5	64
6	70
7	54
8	72
9	79

(*Secretary's abstract.*)

Discussed by Messrs. DRYDEN and GOLDBERG.

RAYMOND J. SEEGER.—The magnetic moment of the proton was determined by sending beams of ortho- and para-hydrogen through a nonhomo geneous magnetic field after the manner of the earlier experiments of Gerlach and Stern.

Fermi made a calculation of the magnetic moment of the hydrogen molecule. The largest contribution to the magnetic moment of a hydrogen molecule comes from the rotation of the protons around the center of mass of the

molecule. The electron spins of the two electrons cancel each other vectorially, and because the electrons rotate more slowly around the center of mass than the protons, acting as though they were being dragged around by the protons, the magnetic moment due to the rotation of the electrons is only about 1–4 as large as that due to the protons. In addition, there is also the magnetic moment due to the spin of the protons. In ortho-hydrogen the two protons are so directed with respect to each other that the magnetic moments due to their spins are additive, whereas, in para-hydrogen they are opposed and cancel each other as do the electron spins.

The magnetic moment of para-hydrogen is, therefore, due altogether to the rotation of the charges around the center of mass, and thus by a determination of the magnetic moment of para-hydrogen this moment can be determined. Subtracting the magnetic moment due to the rotation of the charges from the magnetic moment of ortho-hydrogen, the magnetic moment of two protons is determined.

The experimental result obtained for a single proton is between two and three times the size of a Bohr magneton for a proton ($eh/4\pi mc$, where m is the mass of the proton). (*Secretary's abstract.*)

1058TH MEETING

The 1058th meeting was held in the Cosmos Club Auditorium, October 28th, 1933, President O. S. ADAMS presiding.

Program: B. H. CARROLL: *Present theories of photographic sensitivity.*—Photographic sensitivity is measured in terms of the density developed after a given exposure and is not exclusively dependent on the extent of the photochemical change in the emulsion. Statistical studies of the sensitivity of individual silver halide grains in emulsions, combined with other chemical and physical evidence, indicate that the presence of nuclei of silver sulphide or silver are an important factor in sensitivity. Their function is apparently to increase the developability resulting from a given amount of photolysis of the silver halide, as even in the presence of the nuclei the sensitivity of a grain depends on the absorption of energy by the silver halide of that grain. (*Author's abstract.*)

Discussed by Messrs. MOHLER, HEYL, P. W. WHITE, HUMPHREYS, GISH, KRACEK, SPENCER, H. L. CURTIS and BRICKWEDDE.

R. M. REEVE: *The history of color photography including recent developments,* illustrated by lantern slides and an exhibit of color photographs.

Discussed by Mr. E. W. SPENCER.

F. G. BRICKWEDDE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

Washington at the midwinter meetings.—Washington scientists attended the midwinter meetings of scientific societies in considerable numbers, and took leading parts in their programs. At the Boston meeting of the American Association for the Advancement of Science and affiliated societies, the following Washingtonians presided over the meetings of the organizations designated: R. E. SNODGRASS, Bureau of Entomology, Entomological Society

of America; C. O. Appleman, University of Maryland, American Society of Plant Physiologists; C. L. Shear, Bureau of Plant Industry, Mycological Society of America; W. R. Maxon, U. S. National Museum, American Fern Society; W. D. Leland, chairman of Section L (Historical and Philological Sciences) of the A.A.A.S.

An outstanding address of the meeting was delivered by the Hon. Henry A. Wallace, Secretary of Agriculture, who spoke before the general session on Friday evening, December 29, under the auspices of Section M (Engineering). Mr. Wallace's subject was *The social advantages and disadvantages of the engineering-scientific approach to civilization.* He pointed out that the high degree of individualism natural to most engineers had fitted in well with the highly individualized society which characterized the growing period in American history, but warned his hearers that it cannot be expected to fit into the cooperative or socialized phase which we are now entering. Particularly must the engineer give up his attitude of impersonal detachment, in which he accepted support from men who exploited his work and relieved him from any feeling of responsibility for its social consequences. Mr. Wallace called upon his hearers to promote a broader education and a more humanistic outlook among engineers.

Among the scientific exhibits at the Boston meeting were two prepared by bureaus of the Federal government: one from the Melrose, Mass. station of the Bureau of Entomology, showing methods used in fighting the gipsy moth and other insect pests; the other from the National Bureau of Standards, showing aerodynamic tests of automobile body models, an optical strain gauge, a cement turbidimeter and a test for fatigue in airplane propellers.

During the Christmas week another group of scientific meetings were held in Philadelphia. Among the participating bodies were the Society of American Bacteriologists, at which sixteen papers were presented by Washington scientists; the American Statistical Association, the American Economic Association, the American Farm Economic Association, the Econometric Society and American Association of University Professors. At all of these meetings Washingtonians were duly represented.

The American Anthropological Association, of which Dr. John Montgomery Cooper of the Catholic University of America is secretary, met at Columbus, Ohio.

At the meeting of the Geological Society of America and its affiliated societies, held in Chicago, Dr. W. H. Twenhofel, secretary of the division of geology, National Research Council, presented two papers.

The meeting of the American Psychoanalytic Association, of which Dr. William A. White of St. Elizabeth's Hospital is vice-president, was held in Washington, December 26 and 27.

Washington was also the scene of the joint meeting of the Archaeological Institute of America, The American Philological Association and the Linguistic Society of America, Dec. 27 to 29; George Washington University acted as host institution.

At the request of the World Calendar Association, Inc., Mr. Henry W. Bearce, co-chief of the weights and measures division of the Bureau of Standards, attended meetings held in Philadelphia on December 28, 1933, under the auspices of the American Statistical Association, and presented a paper on calendar revision. Mr. Bearce supported the 12-month, equal-quarters plan of revision, as opposed to the 13 equal months plan.

Bureau of Plant Industry.—Following the retirement of Dr. William A. Taylor as Chief of the Bureau of Plant Industry, United States Department of Agriculture, Knowles A. Ryerson became Chief of the Bureau January 1, 1934. Mr. Ryerson was formerly head of the Division of Foreign Plant Introduction of the Bureau. He holds the degrees of B.S. and M.S. from the University of California.

At the same time Frederick D. Richey, formerly in charge of the Bureau's corn investigations, was appointed Associate Chief of the Bureau, to succeed Dr. Karl F. Kellerman, who has been placed at the head of a new Division of Plant Disease Eradication and Control in the Department. Mr. Richey is a graduate of the University of Missouri with the degree of B.S.A. In his new position he will give special attention to the Bureau's research activities.

Life-saving trap.—A patent on a trap attachment to safeguard small mammals and birds and to make trapping more efficient, recently granted to Albert M. Day, of the Bureau of Biological Survey, has been dedicated by Mr. Day to the free use of the public. The new device is known as the Biological Survey pan spring and is already on the market. It is a small, detachable, thin steel spring to be inserted between the pan and the base of a standard steel trap and can easily be adjusted to prevent the capture of any of the lighter animals common in a given locality. The use of the attachment also helps trappers, who lose time and effort when a trap in a carefully selected location is sprung by unsought animals or by birds.

Radio talks.—The following radio talks have been made by Washington scientists under the auspices of Science Service. They were sent out over the network of the Columbia Broadcasting System: Dr. O. E. Baker, U. S. Department of Agriculture, *The population prospect*, December 13; J. B. Kincer, U. S. Weather Bureau, *Is our climate changing to milder?*, January 3; Dr. Paul S. Galtsoff, U. S. Bureau of Fisheries, *The mystery of the ocean*, January 10.

Assistant Secretary of the Interior Oscar L. Chapman of the Department of the Interior gave a radio talk January 8 over the Columbia Broadcasting System's Station WJSV in Washington. The subject of his talk was the use and value of the national parks.

Recommendations for Weather Bureau.—A committee of the Science Advisory Board, consisting of Dr. Isaiah Bowman, Dr. Karl T. Compton, Charles D. Reed and Dr. Robert A. Millikan, chairman, has presented to the Secretary of Agriculture its preliminary report, recommending certain changes and measures of reorganization in the reporting and forecasting of weather in the United States. Primary recommendations are two: first, that the air-mass analysis method, already in use in certain European countries, be adopted in this country as rapidly as practicable, to supplement the method now in use here: second, that all meteorological activities now conducted by several separate agencies be integrated into one central organization, under the Weather Bureau, except for the activities necessary to the Army and the Navy. In addition to these two major recommendations, the committee also considers the following innovations desirable: a certain decentralization of the general forecast work of the Weather Bureau by the establishment of more numerous district forecast centers in place of the five now existing; an extension of climatological work, looking toward long-

range forecasting; efforts toward cooperation with other countries in the Northern Hemisphere; postgraduate training for Weather Bureau meteorologists, and the establishment of a permanent Weather Bureau Committee to advise on matters of weather service and policy.

Science in the recovery program.—Among the Federal projects approved by the Public Works Administration, five allotments indicate a recognition of the value of scientific research as part of the recovery program.

Two allotments were made to the National Planning Board. One of \$35,000 provides for a program to discover, correlate, and study the researches and surveys now being made throughout the country on such subjects as natural resources, population distribution and trends, health problems, local planning, and any other field which has a direct bearing on national welfare.

A second allotment of \$250,000 to the National Planning Board is to stimulate the preparation of state, regional, local and city plans by sending technical advisers out to visit the local communities.

The Bureau of Chemistry and Soils, U. S. Department of Agriculture, received \$70,000 for the construction of an industrial farm by-products laboratory at Ames, Iowa, where the state agricultural college and experiment station is located.

An experimental study of stream pollution in the upper Mississippi River is provided for by an allotment of \$15,000 to the U. S. Bureau of Fisheries. This Bureau also received \$127,300 for the survey and improvement of streams and lakes in various sections of the country and to provide a scientific basis for such operations.

A new project of the Civil Works Administration includes the exploration of archaeological sites in five different states: Florida, Georgia, North Carolina, Tennessee and California. The work of excavation will provide employment for a total of approximately 1,000 men.

Allocation of more than \$1,750,000 of funds for new construction on government property near Beltsville, Md., as a part of the Public Works program will enable the U. S. Department of Agriculture to develop there a model experiment station for agriculture.

A national experiment in land use, devoted to studying the prevention of soil erosion and providing for removal from cultivation of submarginal land instead of the average land required in the crop reduction programs, is being undertaken cooperatively by the Replacement Crops Section of the Agricultural Adjustment Administration and the Soil Erosion Service of the Department of the Interior. The experiment was authorized upon the recommendation of Secretary of Agriculture WALLACE and Secretary of Interior ICKES. It will cover two million acres of land in 10 different regions.

The Bureau of Fisheries was allotted in August by the Public Works Administration a sum of money amounting to \$309,000 to be expended on some 37 projects including repairs and reconditioning to fish hatcheries, repairs to vessels, improvement to Alaska salmon streams, and the enlargement and continuation of new construction at 4 hatcheries.

NEWS BRIEFS

At the annual meeting of the Board of Trustees of the Carnegie Institution of Washington, held December 15, the following elections were announced: trustees: FRANK B. JEWETT, ROSWELL MILLER, both of New York

City; officers of the board for three ensuing years: ELIHU ROOT, chairman, HENRY S. PRITCHETT, vice-chairman, FREDERIC A. DELANO, secretary.

An aerial mapping project has been undertaken over large selected rural areas in the South, under the auspices of the Civil Works Administration.

A summary of the earthquakes of 1933 based on data compiled by seismologists of the U. S. Coast and Geodetic Survey, shows a total of about forty "earth-shakers." Of these five were destructive to property and human life, causing damage estimated at $41,000,000 and approximately 2,000 deaths.

By cooperation of several scientific agencies with the Tennessee Valley Authority, Indian mounds and other archaeological sites in areas to be excavated, flooded or otherwise disturbed will be given thorough scientific exploration with the objective of salvaging all possible data and material.

It is announced that the International Scientific Radio Union will have its Fifth General Assembly in London, September 12 to 19. This is the international organization for the promotion of radio research. Its Fourth General Assembly was held in Copenhagen in 1931. Dr. A. E. KENNELLY is the President of the Union and Chairman of its American Section. Dr. J. H. DELLINGER, Vice Chairman of the American Section, was recently appointed chairman of the Union's Commission on Radio Wave Propagation.

The International Radio Consulting Committee will have a meeting in Lisbon, beginning September 22. This is one of three advisory committees established by the international telegraph and radio conferences; the other two are on telegraphy and telephony, respectively. The International Radio Advisory Committee has had two previous meetings, The Hague, 1929 and Copenhagen, 1931.

Professor MAX BERGMAN, Director of the Kaiser Wilhelm Institute in Dresden, Germany, gave a lecture entitled *Some recent work in the chemistry of proteins and amino acids* at the George Washington University school of Medicine on Tuesday, November 28, 1933.

The December lecture on the Smith-Reed-Russell series at the School of Medicine, George Washington University, was delivered by Dr. HOWARD T. KARSNER, Department of Pathology, School of Medicine, Western Reserve University. Dr. Karsner's subject was *Rheumatic heart disease.*

More than 48,000 acres of national forest land were planted to trees this fall, the U. S. Forest Service reports. This total covers practically only a half-year, but it is greater than the acreage planted in the national forests in any preceding 12-month period. Plantings in the national forests in 1932 aggregated 24,900 acres, in 1931 they were 26,000 acres. Complete figures for 1933 are not yet available.

PERSONAL ITEMS

CHESTER C. DAVIS has been appointed administrator of the Agricultural Adjustment Act by Secretary of Agriculture WALLACE, with the approval of President ROOSEVELT.

Willis S. Gregg has been appointed chief of the U. S. Weather Bureau, succeeding Dr. Charles S. Marvin, retired.

Dr. Walter C. Lowdermilk has been appointed vice-director of the Soil Erosion Service of the Department of the Interior.

Dr. H. C. Dickinson, chief, heat and power division, National Bureau of Standards, has been appointed by Secretary of Commerce Daniel C. Roper, a member of the committee on uniform traffic laws and ordinances which is charged with conducting a re-survey of the standards recommended by the National Conference on Street and Highway Safety as a basis for traffic laws and ordinances in many of the states and municipalities. The committee will hold its first meeting in Washington, January 17 and 18.

Mr. J. W. Green, of the department of terrestrial magnetism, Carnegie Institution of Washington, returned from Toronto, Canada, December 23, 1933, where he had carried out an inter-comparison of the magnetic standards of the Carnegie Institution of Washington with those of the Meteorological Service of Canada.

Prof. George W. Carver of Tuskegee Institute delivered a lecture at Howard University, December 14.

Miss J. Busse, chief, thermometry section, Bureau of Standards, was elected on January 4 to the office of Vice President of the Quota Club.

The Abbé Georges Lemaître, who has been visiting professor at the Catholic University of America, was designated for the award of the Mendel Medal for 1934 by Villanova College on January 12.

Dr. Neil E. Stevens of the Bureau of Plant Industry was elected President of the American Phytopathological Society at the mid-winter meeting of the Society at Boston.

Obituary

Homer Collar Skeels, botanist, Bureau of Plant Industry, died January 3 at East St. Louis, Illinois, where he had been spending the holidays with his daughter. Mr. Skeels was born July 31, 1873, at Grand Rapids, Michigan, and received his elementary education in that city. He graduated from the Michigan Agricultural College in 1898 with the degree of Bachelor of Science, following which he was in charge of private parks in Joliet, Illinois, for a number of years. He came to the Bureau of Plant Industry in 1907 and served there continuously until his death. During the years spent in the Department of Agriculture, Mr. Skeels built up a very comprehensive collection of economic seeds, now numbering nearly 45,000 samples, which work brought him a nation-wide reputation as an expert in the identification of seeds. He was a fellow of the American Association for the Advancement of Science, and in addition to the Washington Academy of Sciences was a member of the Botanical Society of America, the Botanical Society of Washington and the Biological Society of Washington.

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PETROLOGY.—*Some magmatic problems.*[1] Clarence N. Fenner, Geophysical Laboratory.

For many years the causes of magmatic differentiation have been a subject of very great interest to petrographers. As much as a hundred years ago Scrope suggested that a main cause of variation of magmas was to be found in the sinking of early formed crystals, and Lyell believed this to be the true explanation. Later, various other explanations were advocated by different students, but there was no general agreement as to their efficacy or applicability. The theories were expressed in rather vague general terms and lacked precision.

Comparatively recently N. L. Bowen has shown, by skilful laboratory work and admirable reasoning, in just what manner the separation of successive solid phases from a silicate melt should modify the composition of the residual liquid, and the way in which the results might be applied to natural magmas. His views have gained wide acceptance, and probably most petrologists now regard the essential problems of differentiation as solved.

There is, however, a danger that in the enthusiasm aroused by a notable advance, expectation will be too great, and the possibility of the operation of other processes will be overlooked. There are some geologists who are not yet prepared to accept all the implications of this theory of differentiation, and who feel that it would be well to proceed a little more cautiously and to test more carefully by field observations whether all its requirements are met. They would ask its advocates to give consideration to some apparent discrepancies and endeavor to bring them into accord. It is my purpose to describe certain occurrences that seem incompatible with some of the requirements of the theory as heretofore enunciated. It is hardly necessary to emphasize that our whole conception of the properties of magmas

[1] Presidential address, presented before the Geological Society of Washington, December 13, 1933. Received Dec. 21, 1933.

and of the processes operating in the depths of the earth are involved in the question of differentiation.

All petrologists are familiar with the general principles of the theory of differentiation by crystal separation, but I wish to call special attention to one or two of its main points. It is supposed that the magma that begins to differentiate is basic, probably basaltic. As this cools, crystals separate, and by their separation the composition of the remaining liquid is caused to change progressively. In the normal sequence the liquid passes from basalt through increasingly siliceous andesitic types to a very siliceous rhyolite. The points to be noted are that rhyolite is the *coolest* liquid of the series, and that basic constituents have been eliminated by a *freezing out* process. It follows necessarily that if rhyolitic magma should engulf fragments of basic rock it should not be able ordinarily to melt them or take them into solution, as the minerals of such basic rocks are almost wholly of the sort that, theoretically, have already been frozen out of the magma in the process by which rhyolite has been generated. This idea has been regarded by many writers as almost axiomatic. Accepting unreservedly the view that rhyolites have been formed in this manner and only in this manner, they reason that it would be as illogical to suppose that rhyolite magma could dissolve basic rocks as that a salt solution that had deposited crystals could automatically reverse the process and redissolve the crystals.

On the other hand, in the course of field work, I have come across two remarkable occurrences in which there seems to have been direct solution of large amounts of basic rocks in rhyolite. The incompatibility of these phenomena with theoretical expectations seems to place before petrologists a problem requiring solution before we can be satisfied that the orthodox scheme of differentiation is broad enough to cover all phases of the subject.

The first of these occurrences was met in the Katmai region. At the time of the great eruption of Katmai, the main activity was in the central crater, but important manifestations occurred in the nearby area known as the Valley of Ten Thousand Smokes. We believe that these subsidiary outbreaks had their origin in an intrusive sill that was thrust into the horizontal Jurassic sediments that underlie the valley, and broke through to the surface at numerous points. The chief of these secondary eruptive centers was at Novarupta.

From the nature and distribution of the ejected material of the eruption the chief events may be stated as follows:

At the main crater of Katmai enormous quantities of pumice and

lapilli were ejected in violent explosions, and carried to great distances. At the vents in the Valley of Ten Thousand Smokes the violence was much less, but pumiceous material frothed over the rims and was swept down the Valley in one or more incandescent floods that resembled the glowing clouds of the West Indian eruptions; these we have called the hot sand flows. Novarupta, at the head of the Valley, participated in this phenomenon and was probably a chief contributor to the sand flows. Later, it shot up a spray of fiery fragments which were deposited in thick beds in its immediate vicinity and built up an encircling wall. Its last act, most important for the information on assimilation that it gives, was the slow extrusion of a mass of viscous, glassy lava, which became rigid on the surface as it cooled, and broke into great blocks from the effect of the uplifting forces. This material represents what might be termed a gigantic quenching experiment. It shows in diagrammatic manner the processes of solution and incorporation of xenolithic blocks, arrested at a stage of incomplete digestion by the congealing of the mass.

The new, live magma ejected at Katmai crater and at all the other vents is a very siliceous rhyolite with about 77 per cent silica. Specimens of uncontaminated lava from Katmai, from Novarupta, and from the Valley have been analyzed by several chemists, and they show an almost identical composition. Moreover, there is good reason to believe that the composition of the live magma rising from the depths remained constant from beginning to end of the eruption. Where variations occur there is direct evidence of near-surface contamination.

At all the vents, however, contamination seems to have taken place on a large scale and in similar fashion. Evidence might be cited for each, but it is at Novarupta that it is most easily and convincingly demonstrated.

The uncontaminated rhyolite pumice emanating from all of the vents is a typical pumice, greatly inflated and almost white. It differs much in appearance from the minutely vesicular rhyolitic glass of Novarupta, but this is due simply to their different degrees of inflation. The only crystals that appear in either are rare phenocrysts of quartz and oligoclase. Where the rhyolite has become contaminated the undigested xenoliths have usually the composition of basic andesites of various kinds, and the textures of surface lavas, though sedimentary fragments are fairly plentiful, and there are inclusions of plutonic rock.

The contaminated pumice of the early phases of eruption, which is

found in abundance, shows alternations of white and black bands. The black bands, which are sharply contrasted with the white, contain numerous phenocrysts of labradorite, pyroxene, and magnetite in a brown glass, but in the final stages of reaction these phenocrysts almost disappear in solution, and the siliceous and basic liquids become thoroughly mixed.

In many specimens it is evident that not only was the basic material melted down, but it became so thoroughly impregnated with gases that it participated in the inflation to a pumiceous froth.

These variegated and banded pumices plainly show a remarkable association of two sharply contrasted types of lava, but because of the fragmental nature of the pumice, such material is not well adapted to show how the basic bands originated. Novarupta supplies to perfection the missing evidence. The rock that forms the dome represents the closing stages of activity. The violently explosive phenomena had subsided, and though the rock is shattered, the blocks are large enough to exhibit the mutual relations of the heterogeneous constituents.

Novarupta forms a nearly circular pile of lava about 800 feet in diameter, consisting of rock that is banded on a large scale. Associated with the dark bands and evidently the source from which they originated may be seen thousands of basic xenoliths in all stages of digestion. Some still preserve a sharply bounded, angular outline, but the process of digestion stopped just as others had become softened and were tending toward an elongated form, and as fragments were floating away. Still others reached the stage of disintegration at which they formed lenticular masses of scoria, and finally nothing was left but dark bands. Some of the bands extend for many feet, but at their terminations they always wedge out into the rhyolite. There is no reason to doubt that the rhyolite is the all-embracing matrix and that the dark bands represent included material. Furthermore, the separation between light and dark bands is usually abrupt. This could hardly be so if the two had been stirred together in a violently agitated pool of lava, nor could such a separation have survived the turbulent mixing that the constituents would have undergone, if the basic material had become involved in the rhyolite during its rise from the depths. For this reason, and because the basic material itself has the characteristics of surface andesites, it is believed that the contamination is a near-surface phenomenon.

The features described characterize all the rock of the dome. The specimens and photographs exhibited demonstrate more effectively

than descriptions the processes that were in operation just prior to the congealing of the Novarupta lava. Microscopic examination of this contaminated material shows undoubted evidence of solution, but the best evidence on a microscopic scale is obtained from certain specimens that belong to an earlier stage of activity, when solution was probably going on more vigorously; these were thrown out during the explosive phases.

In thin sections of these specimens some of the minute xenoliths still have a definite form, though the boundaries are very irregular in detail. In many of them the original texture is preserved, and they may be recognized commonly as basic andesites, less often as sediments. Some of the xenoliths became softened, and their shape was distorted. Some were even drawn out into long tongues. The groundmass progressively lost its textural characteristics and became a dark brown glass which has an index of refraction appropriate to an andesitic glass.

Contrary to what we might expect, we find that basic xenoliths were softened and dissolved with more ease than those having the composition of acid andesites.

Further mixture of rhyolite magma and basic liquid is seen in thin sections to present an extremely streaky appearance, and irregular, dark clots are numerous. The phenocrysts of the inclusions consist of pyroxene, iron ore, and plagioclase. Less often hornblende and biotite appear. The phenocrysts were somewhat more resistant to attack than the groundmass, and many of them became free and floated away, but they too yielded to attack and became much corroded, especially the feldspars.

Commonly the feldspars have the composition of acid to basic labradorite, and are much zoned in oscillatory fashion. In their destruction many show a curious effect. The interiors became riddled with brown glass, which had a decided preference for the more calcic zones. This form of replacement went so far that while the outlines of the crystal were preserved, the whole interior, except for small islands of unreplaced feldspar, concordantly oriented, consists of isotropic glass.

In the thick deposits of ejecta from the main crater of Katmai, xenoliths and banded pumices are present, as at Novarupta, but, on the whole, digestion of xenoliths has been much more complete, especially in the later pumices. They carry phenocrysts of labradorite, pyroxene, and ore, from which the matrix has been wholly dissolved away, uniformly dispersed through a frothy glass. Little bipyramids

of quartz are also present, as witnesses of the rhyolitic partnership in the combination, and the bulk composition of the mixture, as shown by analyses, is that of an acid andesite. It does not seem possible to escape the conclusion that in the vents of the Katmai region rhyolite magma melted down and incorporated a large quantity of basic rock. It is especially noteworthy that the introduction of this cold material into the magma, and its assimilation, did not cause precipitation of crystals in the rhyolite. A large amount of heat must have been available, either as excess temperature or as heat of reaction.

I will now take up the second example of assimilation of basic rocks by rhyolite to which I have referred. This was found along Gardiner River in Yellowstone Park. Here many of the conditions were very different from those in the Katmai region, and the resulting phenomena differ in many respects, but assimilation is equally remarkable.

At this place Gardiner River forms the boundary between a wide area of basalt on one side and a still wider area of rhyolite on the other. Both are believed to be of Upper Tertiary age, but the basaltic flow occurred long enough prior to the rhyolite for erosion to produce a surface of considerable relief. At this particular place there was evidently a steep, eastward-facing slope of basalt, with small ridges and other minor irregularities rising from it, and probably with accumulations of boulders lying on its surface and at its foot. From some unknown source enormous extrusions of rhyolite were poured out, which advanced upon this slope and flooded it. Subsequent erosion has worn down the surface in the vicinity so that it is now a nearly level plain, and, what is a very fortunate circumstance, Gardiner River has cut a steep-sided little valley or gorge at just the place best suited to show the contact phenomena.

The contact is very irregular in detail, but, in general, basalt occurs along the sides of the gorge at lower levels whereas the contaminated rhyolite is at higher levels. Small ridges and knobs of basalt protrude through the rhyolite. A little farther back from the river on the west is the wide area of basalt and on the east that of rhyolite. Exposures along the rocky gorge are excellent for a distance of 1,500 feet.

The contaminated rhyolite along the contact contains myriads of basalt xenoliths, ranging in size from those several feet in diameter down to minute chips. These show varying degrees of digestion, and the rhyolite shows varying degrees of contamination. Probably some of this xenolithic material was derived from loose blocks, but certainly not all of it, for the rhyolite had remarkable powers of penetra-

tion. This is plainly demonstrated by the way in which it found its way into the basalt, which is penetrated in places by veins of rhyolite of paper-like thinness. The magma also soaked into some of the inclusions almost as if it were water, and by some process of interchange of constituents not fully understood, the xenolith, while preserving a definite outline, was replaced by rhyolite until only a dim phantom was left. Multitudes were acted upon in this manner, but great quantities of others were disintegrated and incorporated in the rhyolite.

A very remarkable effect is found in a number of places in the exposures along the rocky walls of the gorge. In a typical exposure the rock at the top of the bluffs, 30 feet or so above the water, is largely rhyolite. As we descend the slope, the proportion of rhyolite decreases irregularly, and that of basalt increases, until most of the rock is solid basalt, but this is cut by ramifying and anastomosing veins or dikes of rhyolite. Such dikes locally attain a foot or more in width, but many of them are narrow seams. The rhyolite in these may be quite pure or may be much contaminated with basalt and have an intermediate composition. The dikes decrease in size and number going downward, and at the water's edge very little rhyolite is found. We have here a strange case of a lava flow becoming an intrusive.

In another place, nearly vertical cliffs, 15 or 20 feet high, are composed essentially of unaltered basalt, but locally this is penetrated in the most intricate and irregular manner by more or less contaminated rhyolite. This injected material is in small to minute veinlets. Both the rhyolite and the hybrid rock contain numerous vesicles lined with tridymite crystals, and the passage of gases is indicated by open pockets and pipes of irregular shape. The vertical zone of basalt penetrated in this manner by rhyolitic liquids and gases has a width of 1 or 2 up to 4 or 5 feet. It is made up of rhyolitic veins, seams, and bands; basalt fragments; and hybrid material, inclosed in walls of solid basalt. Forty or fifty per cent of basalt in the mixture is not unusual. In places irregular, dike-like offshoots of rhyolitic affinity extend into the walls, but individually they have no great length and soon fade out.

In some places a zone or system of dikelets of this character has penetrated 40 or 50 feet downward into basalt.

At one place at the top of the cliffs a mass of normal-looking rhyolite with gently inclined flow banding sends out a horizontal tongue, 3 or 4 feet thick, under a capping of basalt for a distance of several feet, and appears much contaminated. Then it becomes thinner and is succeeded by a network of rhyolite veins in basalt. Immediately

adjacent, a vertical pillar of basalt is bounded by rhyolite on the two exposed sides. The rhyolite is contaminated at the contact but has a normal appearance a few feet away.

Minor effects are seen that suggest the action of gases distilled from the rhyolite into the basalt rather than the action of liquid rhyolitic magma. Certain small xenoliths of basalt inclosed in very vesicular, tridymite-bearing rhyolite became granular and porous, and minute tridymite scales were deposited in the pores.

This penetration of veins of rhyolite into solid basalt for long distances indicates a remarkable mobility of the rhyolite magma, even if we assume that it was forced into seams of the basalt under great pressure of overlying magma. This mobility may be ascribed to its high content of volatiles. What seems almost unbelievable is the ability shown by the small tongues of magma that penetrate 25 to 50 feet downward into masses of basalt within narrowly confining walls to heat up and assimilate considerable quantities of cold rock, but the relations seem to leave no room for doubt.

Great powers of assimilation are likewise shown by certain large masses of rock at the top of the cliffs, well above the solid basalt. These are composed of material in which contamination and assimilation progressed so far that a uniform-looking, nearly aphanitic mixture resulted. They have a color ranging from medium gray to a shade nearly as dark as the basalt itself. Their appearance is that of fine-grained andesites. Analyses were made of two homogeneous-looking specimens of this hybrid rock. One has a composition corresponding to 30 per cent basalt and 70 per cent rhyolite, and the other to 69 per cent basalt and 31 per cent rhyolite. The heat necessary to assimilate such large amounts of basalt may have been supplied in part by overlying magma, but this explanation is hardly applicable to the dikelets of rhyolite that penetrated long distances downward into masses of cold rock, corroding and assimilating as they went. These phenomena seem to require either a very highly superheated magma or the development of heat by chemical reactions, but both of these suppositions are excluded in the theory of crystal differentiation as it has been formulated. We seem to have evidence everywhere in this area of the ability of the rhyolite to accomplish things that the theory of crystallization differentiation has declared to be impossible.

Microscopic examination of the rocks confirms in every way the inferences derived from field studies. In the contaminated rocks thin sections reveal inclusions of basalt in rhyolite in various stages of reaction and disintegration. Their borders became greatly corroded,

and fragments floated away in the liquid. In these fragments the minerals of the groundmass commonly underwent partial disintegration, the inclusion taking on a sooty appearance, and in the later stages of solution only sooty specks were left. Phenocrysts in the basalt were set free and became distributed through the rhyolite, but though they persisted longer than the groundmass, they also were attacked.

In the hybrid rocks in which assimilation was so complete that they appear homogeneous, the microscope shows a strange assemblage of minerals indicative of their hybrid origin. Taking as an example the specimen previously mentioned as having a composition equivalent to 70 per cent rhyolite and 30 per cent basalt, we find corroded phenocrysts of olivine, pyroxene, and labradorite derived from the basalt xenoliths, together with quartz and sodic orthoclase derived from the rhyolite magma, scattered through a perfectly uniform-textured fine groundmass derived from mutual reactions. It consists of pyroxene, ore, oligoclase, and orthoclase. In most places in the section all evidence of xenolithic inclusions has disappeared, though here and there traces persist in small, dimly perceptible areas which are a shade darker than the rest. Some of these form narrow borders to clusters of basic xenocrysts, but most of the xenocrysts were freed from their original matrix.

I believe that sufficient evidence has been given to show that both in the Katmai region and in Yellowstone Park rhyolitic magma has been able to dissolve large amounts of basic andesites and basalts. The question may be asked as to why such phenomena have not been more commonly described. The explanation is doubtful. They may have been overlooked or they may be very rare. It is hardly to be expected that a magma appearing at the surface will long retain the temperature required to produce such effects. Also, there are indications that the retention of volatiles is an important factor in the process. Ordinarily lava flows quickly give up their volatiles, but for some strange reason the volatiles are sometimes retained for a long period. Both in the Katmai region and in Yellowstone Park the lavas evidently contained a large amount of volatiles, for they were in a very mobile state at the time that assimilation occurred. This implies in turn that the inner equilibrium appropriate to the small external pressure had not been attained.

When we consider these factors, it does not appear likely that lava flows will often show such results as have been described. The important fact, however, is that they are sometimes capable of producing them.

With plutonic magmas of similar composition it is different, and we might more commonly expect solution. As a matter of fact, granitic bodies show phenomena that might reasonably be interpreted in this manner, but ordinarily investigators have been so convinced of the impossibility of such a process that they have preferred to look for other explanations. Though contamination or hybridization of granites has been frequently recognized as an obvious fact, it has been explained as due to a mechanism by which basic minerals that are out of equilibrium with the acid magma are dissolved in only infinitesimal portions at a time, and new minerals are simultaneously precipitated; in other words, it is the process formulated by Bowen in the reaction principle. This is an important principle and must frequently be operative. When the amount of basic rock is small in comparison with the acid magma, the heat requirements of this process are not excessive, and it is not incompatible with the theory of crystallization differentiation. It has frequently been invoked, but, without depreciating its value when properly applied, we may say nevertheless that it has been used by many writers as a facile means of solving difficulties and of explaining almost everything in the way of assimilation. From the nature of its postulated action it is almost impossible to disprove its application in plutonic bodies in any specific instance, whatever may be the truth of the matter. We should have to show that the disappearance of basic minerals is a process of true solution and is not accompanied simultaneously by the precipitation of new minerals farther along in the reaction series. However, when one observes such opposing phenomena as the common persistence of zoned feldspars in magmas, which illustrate the lack of equilibrium that the reaction principle is supposed to correct, one may doubt whether the principle is as universally operative as has been assumed, but doubt is not disproof. In the Yellowstone rocks, however, the amount of contamination is so great and the phenomena are of such a nature that it seems out of the question to explain the results by this principle. Especially in the veins of rhyolite that penetrated many feet downward into basalt, does it not seem certain that the chilling effect of mere contact with cold walls and xenoliths, to say nothing of assimilation, would be far beyond the capacity of the rhyolite magma to meet unless there were inherent in it heat reserves not recognized in the theory of crystallization differentiation? It seems still more apparent that the reaction principle cannot explain assimilation in the Katmai lavas, for here no precipitation of new minerals occurred—the contaminated lava remained a liquid.

Harker has described beautiful examples of hybrid effects at the contact of granites and granophyres with basic rocks on the island of Skye. Some of the phenomena described by him, such as phantom xenoliths and the penetration of threads of magma into the walls, are matched by those of Yellowstone. In spite, however, of his observation of obvious assimilation on a very considerable scale, he is impressed with the great difficulty of accounting for the solution of any large amount of cold rocks by the new magma. He has written: "The insuperable difficulty to any such theory is that it demands an enormous amount of heat to raise the solid rocks to the point of melting and to melt them." He therefore explains the phenomena on Skye by supposing that the injected rocks were still hot or even partly fluid when the new injections occurred. The evidence for this is not altogether convincing, and it looks as if he had felt forced to make this assumption.

The problem of the heat supply may be freely admitted to be one of great difficulty. A number of writers have recognized that the same problem exists in other phases of volcanism, where it is equally striking. The suggestion has been made that the development of heat is essentially a surface phenomenon, due to the combustion of escaping gases or to the oxidation of ferrous iron in the magma. However, combustion of gases that have left the magma does not develop heat in the place where it is required, and in neither the Katmai nor the Yellowstone hybrid rocks was the ferrous iron oxidized. Chemical analyses and microscopic examination show that beyond doubt. Exothermic heat reactions within the magma itself have also been discussed, and diametrically opposing conclusions have been reached. I doubt if this process has been by any means thoroughly explored; in fact, our knowledge is far from complete regarding the state of combination of the silicate constituents and the dissolved gases in magmas, or of the reactions that take place when the magma rises from a region of great pressure to one of little pressure. In the Katmai and Yellowstone lavas the presence of a considerable amount of volatiles is indicated, and this points to a state of delayed equilibrium. Whether the reactions that finally ensued, permitting the volatiles to escape, were exothermic or not, is a question that must await further information.

However, in these hypothetical exothermic reactions there may possibly be found a means of reconciling phenomena of assimilation with the theory of crystallization differentiation. We may suppose that a rhyolitic magma is formed at depth by the freezing out of basic

phenocrysts. It is therefore a relatively cool liquid; but it may contain within itself latent possibilities of exothermic reactions, which are developed by the change of equilibrium consequent upon its rise to the surface and the escape of volatiles. By this means it may be reheated to such a degree as to be enabled to take into solution the very minerals that had been precipitated.

This is highly speculative, and even if it represents some approximation to the truth, it necessitates a considerable revision of ideas that have been based upon a theory in which such a conception has found no place.

Moreover, if it should eventually be found that exothermic reactions supply a source of heat for assimilation, this fact would not necessarily be dependent upon the generation of rhyolitic magma by crystallization differentiation, or have any relation to it. It would leave the question open as to how rhyolites have been formed.

Without going farther into this, if the phenomena that have actually been observed have the meaning they seem to have, large amounts of basic rocks were dissolved by the rhyolites. In whatever manner this may have been accomplished, it is not satisfactorily explained by current theories. Many subsidiary problems relating to magmas are likewise involved. I will leave all these for future consideration, only expressing the belief that the important requirement now is to examine without bias the facts as they are found in the field.

CHEMISTRY.—*3, 4-dimethoxy-5-chloro-benzylidene di-amides.*[1] RAYMOND M. HANN. (Communicated by ATHERTON SEIDELL.)

Noyes and Forman[2] have recently studied the reactions of a number of liquid aldehydes with acetamide and isolated the resulting aldehyde di-amides. The purpose of the present investigation was an extension of the reaction to include a solid aldehyde and a variety of acid amides.

Raiford and Lichty's[3] orientation of the mono-chloro vanillins provides a foundation for the preparation of chloro veratric aldehydes of known configuration. Methylation of 5-chloro vanillin has yielded 5-chloro veratric aldehyde and this has been condensed under suitable conditions with acetamide, propionamide, n-butyramide, n-caproamide and benzamide.

[1] Received December 2, 1933.
[2] NOYES and FORMAN. J. Amer. Chem. Soc. 55: 3493. 1933.
[3] RAIFORD and LICHTY. J. Amer. Chem. Soc. 52: 4576. 1930.

EXPERIMENTAL

5-Chloro veratric aldehyde (3, 4-dimethoxy-5-chloro benzaldehyde). 50 grams of 5-chloro vanillin was dissolved in 150 cc. 10 per cent NaOH and 600 cc. H_2O, heated to complete solution of the separated sodium salt, cooled and held at 35° C., 100 cc. of dimethyl sulfate added to the constantly stirred solution, and the solution maintained alkaline to phenolphthalein by addition of 10 per cent NaOH (10 cc. every 3 to 5 minutes, a total of about 1400 cc. being required). When about 250 cc. of NaOH had been added on oil separated and was brought into solution by addition of 50 cc. more dimethyl sulfate. When this second portion of sulfate had reacted the alkaline solution again separated an oil and on cooling this solidified. The solid was filtered off, washed with H_2O and the filtrate acidified, and 3.7 grams unchanged chloro vanillin recovered. Yield of crude material 50 grams; quantitative. The substance was recrystallized from 50 per cent alcohol for analysis.

5-Chloro veratric aldehyde crystallizes in colorless, soft, glistening needles, and melts to a clear colorless oil at 57° C. (cor.).

Analysis: 0.2182 gram gave 0.1553 gram AgCl equivalent to 17.61 per cent Cl. Theory for $C_9H_9O_3Cl = 17.68$ per cent Cl.

5-Chloro-veratrylidene di-amides. One molecular portion of aldehyde, two of the desired amide, and 1 cc. of glacial acetic acid were heated at 140° C. in a small flask for 15 hours. Water was given off when acetamide and propionamide were used and a solid brown cake resulted. The other amides gave brown liquid melt which solidified on cooling. The melt was brought into solution by refluxing with alcohol and filtered through char. The colorless filtrate soon separated crystalline material which was filtered, washed with alcohol, recrystallized from alcohol to constant melting point, and analyzed. The yields are almost quantitative. The data are summarized in table 1.

TABLE 1. PROPERTIES OF 3, 4-DIMETHOXY-5-CHLORO-BENZYLIDENE DI-AMIDES

Product 3, 4-Dimethoxy-5-Chloro Benzylidene	M. P. °C. (cor.)	Appearance	Nitrogen Analysis Per cent	
			Calc'd.	Found
Di-acetamide	244–5	Colorless, crystalline powder	9.32	9.23
Di-propionamide	235	Colorless fine acicular needles	8.52	8.30
Di-n-butyramide	204–5	Colorless, glistening platelets	7.85	7.50
Di-n-caproamide	172–3	Colorless needles	6.79	6.76
Di-benzamide	217	Brilliant, soft, colorless needles	6.60	6.63

SUMMARY

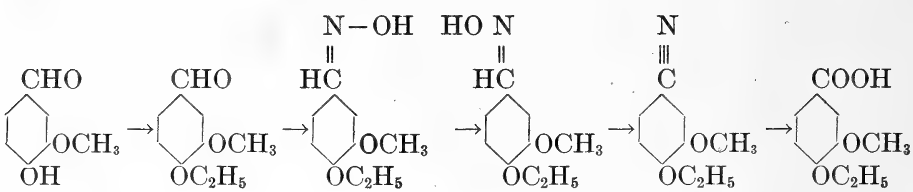
The aldehyde amide condensation reaction has been extended to include a solid aromatic aldehyde with various aliphatic amides.

CHEMISTRY.—*The isomeric oximes of ethyl vanillin.*[1] RAYMOND M. HANN. (Communicated by ATHERTON SEIDELL.)

Ethyl vanillin (3-methoxy-4-ethoxy benzaldehyde) has long been known, having been prepared by Tiemann[2] in connection with his exhaustive research upon the structure of coniferin. The original method of preparation, the interaction of vanillin and ethyl iodide in the presence of ethyl iodide, has since been displaced by the cheaper and simpler method of ethylation by diethyl sulfate in alkaline solution.[3]

In furthering an investigation upon the relationship between structure and taste in the vanillin series it was desired to investigate some properties of the syn-oxime of ethyl vanillin. Because it was necessary to prepare the anti-oxime, it seemed desirable to continue the study of these derivatives and to correlate them with some known compounds of the ethyl vanillin series.

The present paper reports the result of these investigations, and outlines the indirect synthesis of ethyl vanillic acid in accordance with the following series of reactions.



EXPERIMENTAL

Ethyl vanillin (3-methoxy-4-ethoxy benzaldehyde). Twenty-five grams of vanillin were dissolved in 75 cc. of 10 per cent NaOH solution and 200 cc. of H_2O added. To the constantly stirred clear yellow solution 45 cc. of practical diethyl sulfate (theory for 2 moles. 42.8 cc.) were added and the suspension gradually heated to 65° C. when reaction occurred. The solution was maintained alkaline to phenolphthalein by addition of increments of 10 cc. 10 per cent NaOH at

[1] Received December 2, 1933.
[2] TIEMANN. Ber. Deutschen Chem. Gesell. **8**: 1128. 1875.
[3] BARGER, EISENBRAND, and SCHLITTLER. Ber. Deutschen Chem. Gesell. **66**: 453. 1933.

approximate five minute intervals, a total of 70 cc. being required. The solution was then heated rapidly to boiling, 100 cc. H_2O added and upon cooling to 50° C. crystallization occurred. When cold, the ethyl vanillin was filtered and dried. Yield 24 grams. A second crop of 0.8 gram crystallized from the other liquor. Total yield 24.8 grams or 84 per cent of theory. This material was used directly for further work. Recrystallization from 4 parts of 50 per cent ethyl alcohol gave a product melting at 65° C. (corr.) in agreement with Tiemann.

Ethyl vanillin anti-oxime. Twenty grams of crude ethyl vanillin, 8 grams of hydroxylamine hydrochloride, 10 grams of sodium bicarbonate and 50 cc. of 95 per cent alcohol were heated under reflux for one half hour. The addition of 200 cc. H_2O caused separation of an oil which rapidly solidified. Cooled, filtered, and recrystallized from 4 parts of 50 per cent alcohol the oxime was obtained in colorless granular prisms which melt at 102° C. (corr.) to a clear colorless oil.

Analysis: 0.1137 gram consumed 5.80 cc. 0.1 N acid equivalent to 7.14 per cent N. Theory for $C_{10}H_{13}O_3N$ is 7.18 per cent N.

Ethyl vanillin anti-oxime acetate. One and nine-tenths grams of the anti-oxime was heated to boiling with 10 cc. acetic anhydride, the excess anhydride decomposed by $NaHCO_3$, and the separated solid recrystallized from 50 per cent alcohol. The compound crystallized in fine glistening prismatic crystals which melt at 69° C. (corr.) to a clear colorless oil.

Analysis: 0.0694 gram consumed 2.9 cc. 0.1 N acid equivalent to 5.85 per cent N. Theory for $C_{12}H_{15}O_4N$ is 5.91 per cent N.

Ethyl vanillin syn-oxime. Twelve grams of crude ethyl vanillin anti-oxime was dissolved in 150 cc. ether and the hydrochloride precipitated by introduction of dry HCl and 25 cc. H_2O, and the suspension added to a solution of 25 grams of Na_2CO_3 in 250 cc. H_2O. An oil came down which rapidly solidified. Yield 10 grams. The solid was recrystallized several times from 50 per cent alcohol, and finally obtained in colorless brilliant crystals which melt at 98° C. (corr.) to a clear colorless oil.

Analysis: 0.1069 gram consumed 4.5 cc. 0.1 N acid aquivalent to 7.21 per cent N. Theory for $C_{10}H_{13}O_3N$ is 7.18 per cent N.

Ethyl vanillonitrile (3-methoxy-4-ethoxy benzonitrile). Five grams of ethyl vanillin syn-oxime was dissolved in 10 cc. acetic anhydride, heated to 30° C., and allowed to stand for ten minutes. The excess anhydride was decomposed by addition of 200 cc. 10 per cent Na_2CO_3 solution and the separated nitrite filtered and washed with H_2O. Yield 4.5 grams. Recrystallized from dilute alcohol it melted at 102° C.

in agreement with Keffler[4] who prepared it by the action of ethyl iodide on the potassium salt of ethyl vanillin.

Ethyl vanillic acid (3-methoxy-4-ethoxy benzoic acid). One gram of ethyl vanillonitrile was boiled with 20 cc. of 10 per cent NaOH solution for one half hour, the solution cooled, and the acid precipitated by dilute HCl. It was recrystallized from 25 per cent alcohol, separating in beautiful colorless needles which melt at 193–4° C. in agreement with Tiemann.

SUMMARY

Ethyl vanillin has been oximated to the anti-oxime, which has been isomerized to the syn-form, and the latter by the action of acetic anhydride converted to 3-methoxy-4-ethoxy benzonitrile. Alkaline hydrolysis of the nitrile leads to the previously described ethyl vanillic acid, obtained by direct oxidation of ethyl vanillin.

[4] KEFFLER. Jour. Chem. Soc. 119: 148. 1921.

PALEONTOLOGY.—*New fossil fresh-water Mollusca from the Cretaceous and Paleocene of Montana.*[1]

LORIS S. RUSSELL, Geological Survey, Ottawa, Canada. (Communicated by John B. Reeside, Jr.)

Dr. G. G. Simpson, of the American Museum of Natural History, recently submitted to the writer a collection of non-marine mollusks from central and southwestern Montana, material obtained under the auspices of the United States National Museum. Most of the specimens pertain to described species, but at least two new species and two varieties appear to be represented. The writer is indebted to Dr. Simpson for the opportunity of studying this collection, and to the authorities of the U. S. National Museum for permission to publish the following descriptions.

PELECYPODA: UNIONIDAE

Elliptio silberlingi, sp. nov.

Figs. 1 and 2.

Type.—U. S. National Mus. No. 75287A; paratype, No. 75287B. From the Eagle coal mine, Bear Creek, Carbon county, Montana. Upper Paleocene ("Bear Creek" horizon).

Description.—Shell moderately large, elongate-ovoid, flattened. Beak low, placed near anterior extremity, sculptured with two fine plications, slightly

[1] Published with the permission of the Director, Geological Survey, Department of Mines, Ottawa, Canada. Received Oct. 26, 1933.

double-looped; also a pair of fine, diverging ridges extending from posterior end of beak toward the posteroventral extremity. Anterior margin well rounded; ventral margin sinuous, convex in front, slightly concave near midlength; posterior extremity low, narrowly rounded, produced; posterior dorsal margin broadly convex. A broad, shallow sinus extending downward and somewhat backward from umbo. Surface marked by fine and coarse lines of growth. Length of holotype, 98.8 mm.; height, 44.6 mm.; thickness, as preserved, 16.3 mm.

Remarks.—This species clearly belongs to the group of "*Unio*" *priscus* and its relatives, but may be distinguished by the elongate outline and produced posterior, as well as by the reduced beak sculpture. In a forthcoming revision of the Canadian fossil Unionidae the writer erects a new subgenus for the "*Unio*" *priscus* group under the genus *Elliptio*. More particularly, the present species closely resembles, and probably is descended from, the Judith River form identified by Stanton[2] as *Unio subspatulatus*.

The new species is named for Mr. Albert C. Silberling, of Harlowton, Montana, in recognition of his services to paleontology.

Medionidus? senectus (White)

Unio senectus, White, U. S. Geol. and Geog. Surv. Terr., Ann., Rept. for 1878, pt. 1, p. 69. *pl. 28, fig. 1, pl. 29, fig. 3.* 1883.

Remarks.—In his revision of Canadian fossil unionids, mentioned above, the writer tentatively refers this species to the genus *Medionidus* Simpson. This reference is based principally on the presence of postumbonal radiating sculpture. It is probable that "*Unio*" *senectus* represents a genus absent from the living fauna.

Medionidus? senectus declivis, var. nov.

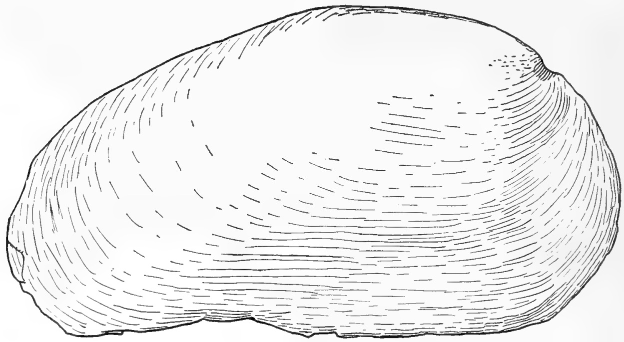
Fig. 3.

Type.—U. S. National Mus. No. 75288; from SE. $\frac{1}{4}$ of SE. $\frac{1}{4}$, Sec. 10, T. 5 N., R. 13 E., Sweetgrass county, Montana. Paleocene, "about 4000 feet above base of "No. 3," with highest mammals from Crazy Mountain Field, probably post-Torrejon."[3]

Description.—Shell elongate, tapering posteriorly; posterior dorsal margin broadly convex, sloping to the narrowly rounded posteroventral extremity. Postumbonal radiating sculpture as in *M.? senectus* but more obscure. Length of holotype, 76.4 mm., height, 41.2 mm.; thickness, as preserved, 16.8 mm.

Remarks.—Shells of this variety are associated at the type locality with typical examples of *M.? senectus*, from which they differ in the characters given above. Some examples from the upper Ravenscrag beds of Saskatchewan show characters intermediate between those of *M.? senectus senectus* and the present variety. The differences may be only sexual, but it is note-

[2] U. S. Geol. Surv., Bull. **257**: 107. *pl. 13, fig. 1.* 1905.
[3] Simpson, personal communication.



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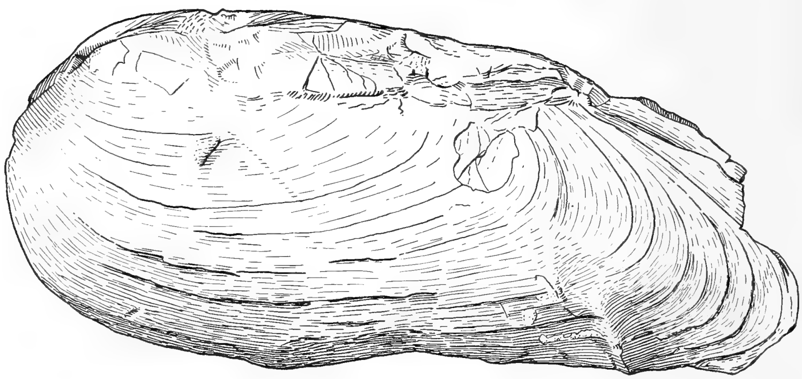

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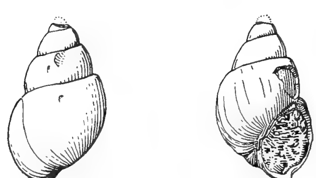

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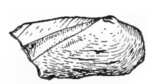

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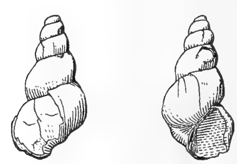

A B

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Fig. 1.—*Elliptio silberlingi*, sp. nov., holotype, ×1.
Fig. 2.—*Elliptio silberlingi*, sp. nov., paratype, showing umbonal markings, ×1.
Fig. 3.—*Medionidus? senectus declivis*, var. nov., holotype, ×1.
Fig. 4.—*Campeloma vetulum pegmate*, var. nov., holotype, ×1. A, dorsal view; B, ventral view.
Fig. 5.—*Goniobasis ursarivulensis*, sp. nov., holotype, ×1. A, dorsal view; B, ventral view.

worthy that the variety *declivis* appears to be absent from the Judith River and contemporary faunas. All examples of this age seen by the writer have the short outline and the broad posterior extremity.

GASTROPODA: VIVIPARIDAE

Campeloma vetulum (Meek and Hayden)

Paludina vetula, Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., **8**: 121. 1857.
Campeloma vetula, Meek, U. S. Geol. Surv. Terr., Rept., **9**: 587. *pl. 42, figs. 14a, 14b.* 1876.

Campeloma vetulum pegmate, var. nov.

Fig. 4.

Type.—U. S. National Mus. No. 75289; SW. ¼ of NW. ¼, Sec. 8, T. 6 N., R. 18 E., Wheatland county, Montana. About 75 feet above base of Judith River formation, Upper Cretaceous.

Description.—Shell as in *C. vetulum*, but with a narrow, distinct shelf along the posterior (apical) border of the whorls; body whorl relatively less ventricose. Length of holotype (first whorl missing), 20.1 mm.; width, 11.9 mm.; length of aperture, 9.7 mm.

Remarks.—This variety occurs associated with *C. vetulum vetulum* in the Pale beds (upper Belly River) of Alberta.

MELANIIDAE

Goniobasis ursarivulensis, sp. nov.

Fig. 5.

Type.—U. S. National Mus. No. 75290; from the Eagle coal mine, Bear Creek, Carbon county, Montana. Upper Paleocene ("Bear Creek" horizon).

Description.—Shell of moderate size, elongate-concoid. Spire tapering, length almost two-thirds that of shell; volutions about five, prominently convex; suture linear, broadly impressed. Inner lip of aperture nearly straight, outer lip strongly convex. Surface marked by numerous fine and a few coarse lines of growth, and occasionally by obscure revolving markings. Length of holotype, 17.8 mm.; width, 9.0 mm.; length of aperture, as preserved, 6.7 mm.

Remarks.—This species closely resembles, and probably is descended from, *G. sanctamariensis* Russell[4] from the St. Mary River formation of Alberta. The present species may be distinguished by the more slender shell, and the lesser prominence of the whorls, which do not show numerous fine, revolving lines. The distinction between these two species may be of value in differentiating Upper Cretaceous from Paleocene strata.

[4] Canadian Field-Nat. **46**: 81. *fig. 4.* 1932.

ZOOLOGY.—*New genera and species of blood flukes from a marine turtle, with a key to the genera of the family Spirorchidae.*[1] EMMETT W. PRICE, Bureau of Animal Industry. (Communicated by BENJAMIN SCHWARTZ.)

Among some trematodes collected by Dr. B. G. Chitwood and the writer from a marine turtle, *Chelone mydas*, which died in the National Zoological Park, March 8, 1932, were a number of specimens belonging to the Spirorchidae, a family proposed by Stunkard (1921) for trematodes occurring in the circulatory system of turtles. These specimens were collected for the most part from washings of the digestive tract, but in view of their affinities with species which have been described from the blood vessels of other cold-blooded hosts, it appears certain that they had escaped from the blood vessels during evisceration; a few specimens were collected also from washings of the body cavities. These specimens were found to represent four new species and three new genera, the descriptions of which are given in this paper. In order to differentiate the new genera from related genera, a key to the genera of the family Spirorchidae is appended.

Neospirorchis, new genus

Generic diagnosis.—Spirorchidae: Body greatly elongated, threadlike, subcylindrical. Cuticula provided with fine transverse ridges but without spines. Oral sucker moderately developed; acetabulum absent. Esophagus, especially the posterior half, surrounded by unicellular glands; intestinal tract similar to that of schistosomes. Genital aperture lateral, in posterior half of body. Testis slender, more or less spiral, extending to intestinal union; vas deferens arising from posterior pole of testis; cirrus pouch present. Ovary slender, spiral, situated along posterior portion of testis. Seminal receptacle and Laurer's canal absent. Vitellaria extending from intestinal bifurcation to near level of genital aperture. Eggs without polar processes. Parasitic in marine turtles.

Type species.—*Neospirorchis schistosomatoides,* new species.

Neospirorchis schistosomatoides, new species

Figs. 1–2.

Description.—*Neospirorchis:* Body threadlike, 7.45 to 9.5 mm. long by about 140 to 220μ wide; pretesticular portion of body slightly flattened dorsoventrally, posttesticular portion cylindrical or subcylindrical. Cuticula without spines but marked with fine transverse ridges. Oral sucker subterminal, 32 to 40μ in diameter; acetabulum absent. Esophagus 595 to 680μ long, consisting of two parts about equal in length; anterior part slender, posterior part about twice the width of anterior part and surrounded by unicellular glands. Intestinal branches slightly sinuous, uniting near level of

[1] Received November 18, 1933.

anterior pole of testis, forming a common cecum terminating near posterior end of body. Excretory pore terminal; excretory vesicle Y-shaped. Genital aperture lateral, about 1 to 1.2 mm. from posterior end of body. Cirrus pouch weakly developed, enclosing a long, slender, muscular cirrus; cirrus apparently protrusible, but not actually protruded in any of the specimens available. Vas deferens relatively long and convoluted, arising from posterior pole of testis. Testis long, slender, more or less spiral, and extending anteriorly as far as level of intestinal union. Ovary long, slender, more or less spiral, and extending anteriorly from a point posterior to genital aperture for about one-third the length of testis. Oviduct slender, extending posteriorly to an ootype about 500μ from posterior end of body; oviduct joined here by vitelline duct and continued anteriorly as a slender tube expanding to form the uterus. Seminal receptacle and Laurer's canal absent. Vitellaria well developed, extending in intercecal field from posterior end of esophagus to intestinal union, thence continuing dorsal to common cecum and terminating near level of genital aperture. Vitelline duct single, extending posteriorly to ootype and expanding there to form a large vitelline reservoir. Uterus slightly tortuous, containing 7 to 15 eggs, extending anterior to genital aperture, then turning posteriorly. Eggs oval, 44μ long by 32μ wide, without polar prolongations.

Host.—*Chelone mydas.*

Location.—Visceral blood vessels.

Locality.—United States (Washington, D. C.).

Type specimen.—U. S. N. M. Helm. Coll. No. 32563; paratypes No. 32564.

Neospirorchis schistosomatoides appears to be more or less closely related to *Unicaecum ruszkowskii*, a species described by Stunkard (1925, 1927) from *Pseudemys scripta*, but differs from that species in the form of the digestive tract and in the point of origin of the vas deferens. In *N. schistosomatoides* the digestive tract is of the same type as that found in members of the family Schistosomatidae, while in *U. ruszkowskii* the digestive tract consists of a single cecum. The vas deferens in *N. schistosomatoides* arises from the posterior pole of the testis, while in *U. ruszkowskii* it arises from the anterior pole of the testis, and extends parallel to the testis for its entire length.

The form of the digestive tract in *N. schistosomatoides* is of especial interest, since this is the first species of blood fluke from cold-blooded vertebrates which has a digestive system of the type characteristic for blood flukes occurring in warm-blooded vertebrates. A tendency toward fusion of the intestinal ceca to form a digestive tract of the schistosome type has been reported by Stunkard (1923) in specimens of *Spirorchis.*

Amphiorchis, new genus

Generic diagnosis.—Spirorchidae: Body slender, subcylindrical. Cuticula marked with fine transverse ridges. Oral sucker and acetabulum present. Esophagus slender, surrounded by unicellular glands; intestinal ceca slender, not uniting posteriorly. Cirrus pouch well developed, containing a short cirrus, internal seminal vesicle and prostate cells; external seminal vesicle anterior to cirrus pouch. Testes two in number, one anterior and the other posterior to cirrus pouch and ovary. Seminal receptacle and Laurer's canal

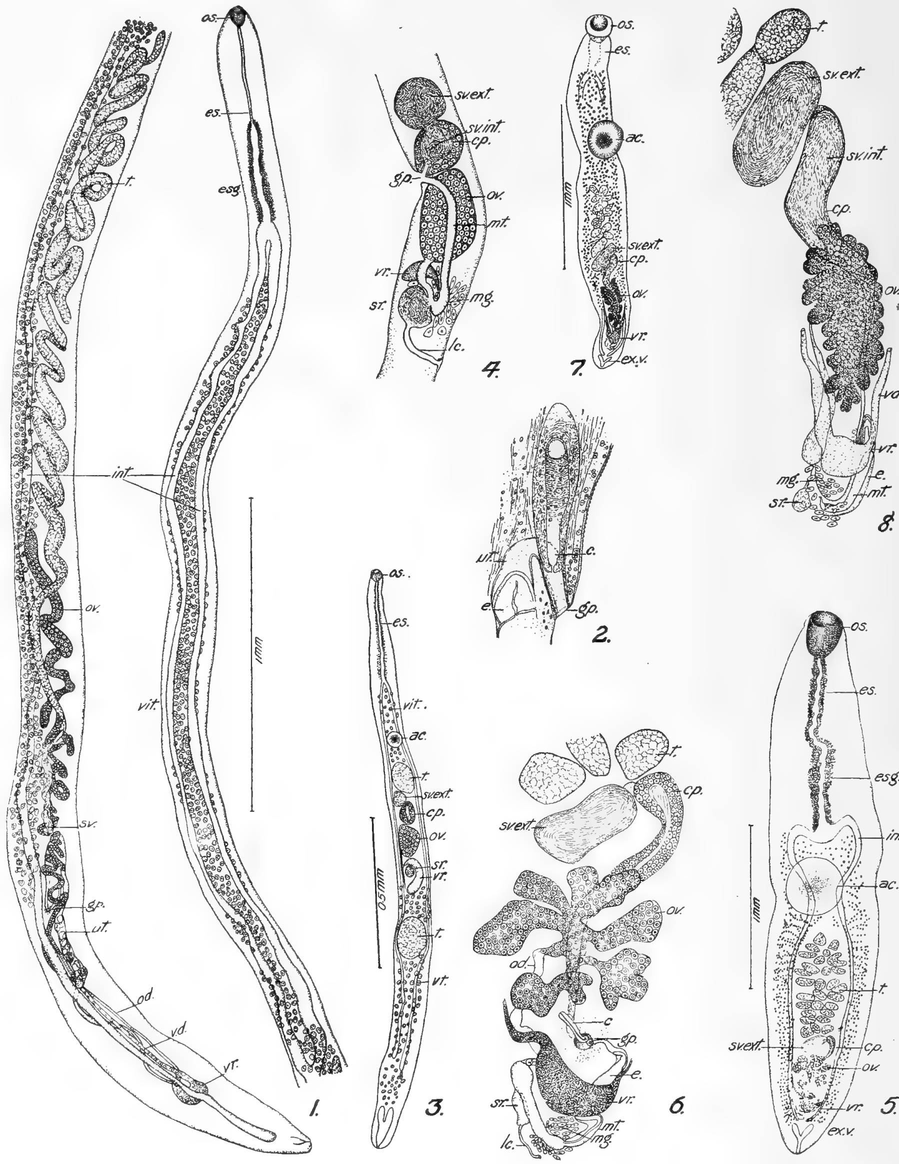

Fig. 1. *Neospirorchis schistosomatoides.* Entire worm. Fig. 2. *N. schistosomatoides.* Terminal portions of genital system. Fig. 3. *Amphiorchis amphiorchis.* Entire worm; ventral view. Fig. 4. *A. amphiorchis.* Genital complex; reconstructed from serial sections. Fig. 5. *Learedius learedi.* Entire worm; ventral view. Fig. 6. *L. learedi.* Genital complex; greatly enlarged. Fig. 7. *L. similis.* Entire worm; ventral view. Fig. 8. *L. similis.* Genital complex; greatly enlarged.

ac.	Acetabulum	*mg.*	Mehlis' gland
c.	Cirrus	*mt.*	Metraterm
cp.	Cirrus pouch	*od.*	Oviduct
e.	Egg	*ov.*	Ovary
es.	Esophagus	*sr.*	Seminal receptacle
esg.	Esophageal glands	*sv. ext.*	External seminal vesicle
ex. v.	Excretory vesicle	*sv. int*	Internal eminal vesicle
gp.	Genital aperture	*t.*	Testis
int.	Intestine	*vit.*	Vitellaria
lc.	Laurer's canal	*vr.*	Vitelline reservoir

present. Vitellaria consisting of two groups of follicles, one group extending from intestinal bifurcation to anterior testis, and the other from posterior end of vitelline reservoir to near posterior end of body. Parasitic in blood vessels of marine turtles.

Type species.—Amphiorchis amphiorchis, new species.

Amphiorchis amphiorchis, new species

Figs. 3–4.

Description.—Amphiorchis: Body elongated, 1.87 to 2.2 mm. long by 120 to 148μ wide at level of posterior testis, oval to subcylindrical on cross section. Cuticula without spines but marked by fine transverse striations. Oral sucker subterminal, 40 to 44μ in diameter; acetabulum circular, 40 to 64μ in diameter, 476 to 510μ from anterior end of body. Esophagus 255 to 320μ long, surrounded by unicellular glands; intestinal ceca slender, terminating blindly about 280μ from posterior end of body. Excretory pore terminal; excretory vesicle Y-shaped, the branches slightly longer than the stem. Genital aperture median, immediately anterior to ovary. Cirrus pouch oval, 60 to 80μ long by 48 to 60μ wide, enclosing a short, thick cirrus, a moderately large internal seminal vesicle, and numerous prostate cells; external seminal vesicle more or less globular, 40 to 60μ in diameter, immediately anterior to and slightly to right of cirrus pouch. Anterior testis oval, 100 to 120μ long by 80 to 88μ wide, in front of external seminal vesicle; posterior testis oval, 140 to 190μ long by 100 to 120μ wide, situated a short distance caudal to posterior end of vitelline reservoir and separated from it by a band of vitelline follicles. Ovary irregularly oval, 120 to 140μ long by 54 to 80μ wide, between testes and immediately posterior to cirrus pouch. Seminal vesicle globular, 24 to 40μ in diameter, posterior to ovary and situated in curve of vitelline reservoir. Mehlis' gland present, consisting of relatively few large cells; Laurer's canal relatively large, opening in mid-dorsal line a short distance posterior to seminal receptacle. Vitelline reservoir large and curved; vitellaria consisting of two groups of follicles, one group between intestinal bifurcation and anterior testis and the other between posterior end of vitelline reservoir and posterior end of body. Metraterm simple, muscular. Eggs not observed.

Host.—Chelone mydas.

Location.—Visceral blood vessels.

Locality.—United States (Washington, D. C.).

Type specimen.—U. S. N. M. Helm. Coll. No. 32565, paratypes No. 32566.

The genus *Amphiorchis* appears to be more closely related to the genera *Hapalotrema* Looss, *Spirhapalum* Ejsmont, and *Hapalorhynchus* Stunkard than to any of the other genera of Spirorchidae. *Amphiorchis amphiorchis* is more slender and the testes are simple instead of being divided into preovarial and postovarial groups of follicles as is the case of the types of *Hapalotrema* and *Spirhapalum.* In body form it resembles most closely *Hapalorhynchus gracilis* Stunkard, but in that species the genital aperture is dorsal and the anterior testis is situated posterior to the genital aperture and seminal vesicle, while in *A. amphiorchis* the genital aperture is ventral and the anterior testis is anterior to the seminal vesicle.

Learedius, new genus

Generic diagnosis.—Spirorchidae: Body elongate, slightly constricted equatorially, flattened dorsoventrally. Oral sucker and acetabulum present. Esophagus long and surrounded by unicellular glands; intestinal ceca slender, not uniting posteriorly. Genital aperture median or slightly to left, near posterior end of body. Cirrus pouch present, largely filled by internal seminal vesicle; external seminal vesicle present. Testes numerous, preovarial. Ovary deeply lobed, posttesticular. Laurer's canal present. Eggs with polar prolongations. Parasitic in circulatory system of marine turtles.

Type species.—*Learedius learedi*, new species.

Learedius learedi, new species

Figs. 5–6.

Description.—*Learedius:* Body elongated, 3.4 mm. long by 690μ wide, slightly constricted near equator of body, flattened dorsoventrally. Cuticula with verrucae similar to, but smaller than, those of species of *Schistosoma*. Oral sucker cup-shaped, 280μ long by 240μ wide, oral aperture subterminal; acetabulum circular, 340μ in diameter, pedunculated, near equator of body, Esophagus slightly tortuous, 1.02 mm. long, surrounded by unicellular glands. Intestinal ceca slender, curving inward at level of acetabulum, terminating near posterior end of body. Excretory pore terminal; excretory vesicle Y-shaped, the branches of about the same length as stem. Genital aperture about 360μ from posterior end of body, slightly left of median line. Cirrus pouch shaped somewhat like an elongated letter S, its base enlarged and lying about 360μ from genital aperture, containing a slender internal seminal vesicle, numerous prostate cells, and a protrusible cirrus; external seminal vesicle transversely elongated, 144μ long by 60μ wide, to right of base of cirrus pouch. Testes 28 in number, in intercecal field between external seminal vesicle and acetabulum. Ovary deeply lobed, more or less dendritric, 240μ long by 240μ wide, posterior to external seminal vesicle. Oviduct long and slender, arising at right side of ovary and expanding posteriorly to form an elongated ootype; seminal receptacle postero-dorsal of ootype; Laurer's canal slender, opening in mid-dorsal line near level of ends of ceca. Vitelline reservoir large, anterior to ootype. Vitellaria consisting of small follicles forming a transverse band across body between intestinal bifurcation and level of posterior margin of acetabulum, then extending posteriorly in extracecal fields to level of tips of ceca. Metraterm short and containing a single egg. Egg fusiform, about 210μ long (including polar prolongations) by 28μ wide.

Host.—*Chelone mydas.*

Location.—Circulatory system.

Locality.—United States (Washington, D. C.).

Type specimen.—U. S. N. M. Helm. Coll. No. 32567.

Learedius similis, new species

Figs. 7–8.

Description.—*Learedius:* Body elongated, 2.2 mm. long by 320μ wide, slightly constricted at level of acetabulum. Cuticula with verrucae larger and less numerous than those of *L. learedi*. Oral sucker subterminal, 160μ in diameter; acetabulum circular, 240μ in diameter, pedunculated, about

750μ from anterior end of body. Esophagus about 170μ long, surrounded by unicellular glands; intestinal ceca slender, extending to near posterior end of body. Excretory pore terminal; excretory vesicle Y-shaped, the limbs longer than stem. Genital aperture almost median, 260μ from posterior end of body. Cirrus pouch somewhat S-shaped, its base about 1 mm. from genital aperture, almost completely filled by internal seminal vesicle; external seminal vesicle 180μ long by 80μ wide, situated as in *L. learedi*. Testes arranged as in *L. learedi*, the exact number not ascertainable in the specimen available. Ovary lobulated, 260μ long by 120μ wide, between external seminal vesicle and vitelline reservoir, ventral to cirrus pouch. Oviduct dilated, arising from right side of ovary; ootype short and surrounded by Mehlis' gland; seminal receptacle present; Laurer's canal not observed. Vitellaria extending from level of intestinal bifurcation to about middle of ovary and occupying entire intercecal field anterior to testes. Egg fusiform, 234μ long (including polar prolongations) by about 12μ wide.

Host.—*Chelone mydas.*
Location.—Circulatory system.
Locality.—United States (Washington, D. C.).
Type specimen.—U. S. N. M. Helm. Coll. No. 32568.

The descriptions of *Learedius learedi* and *L. similis* are each based upon a single specimen, but in view of certain distinct differences they cannot be regarded as the same species. These differences are as follows: *L. similis* has a much shorter esophagus and the intestinal bifurcation occurs much farther cephalad of the acetabulum than in *L. learedi;* the testes are much less numerous than in *L. learedi;* the cirrus pouch is relatively much longer and encloses a larger internal seminal vesicle and fewer prostate cells than does that of *L. learedi;* the ovary, while distinctly lobed, does not present the dendritic appearance of that structure in *L. learedi;* and the vitellaria in *L. similis* extend posteriorly only as far as the level of the middle of the ovary, while in *L. learedi* they extend to the level of the tips of the ceca. The egg is also somewhat different in the two species, that of *L. similis* being longer and more slender than that of *L. learedi.*

In addition to the two species just described, *Distoma constrictum* Leared must also be included in the genus *Learedius.* This species was described by Leared (1862) from the "edible turtle" (also referred to in the same paper as the "common turtle"), the specimens having been collected from the heart, and submitted to Cobbold who regarded them as larval flukes. Almost no description was given for this species aside from the size—"Their average length was a line and a half, and the breadth about one third of this,"—and a few minor comments on the shape of the body and on the configuration of the digestive tract. Judging from the figure accompanying the description, the species is closely related to *Learedius learedi* described in this paper and may actually be the same. However, the writer feels that the two forms should be regarded as distinct until such time as a restudy can be made of specimens from the same host and from the same locality as that from which Leared's specimens were obtained. The apparent points of difference be-

tween the two forms are the longer and more serpentine esophagus and the smaller number of testes in Leared's species as compared with these structures in *L. learedi.*

In reviewing the literature concerning *Distoma constrictum* Leared, a situation was discovered which involves the validity of the name of Leared's species as well as of the status of forms subsequently described by Monticelli (1896) and by Looss (1899), which were regarded by them as the same as *D. constrictum* Leared. This situation is briefly summarized as follows:

Distoma constrictum Leared, 1862, is preoccupied by *D. constrictum* Mehlis, in Creplin, 1846, making Leared's *constrictum* a homonym and, consequently, unavailable. This fact was noted by Monticelli (1896) who described under the name of *Mesogonimus constrictus* (Leared) a blood fluke from "*Thalassochelys caretta* Linn." Despite the fact that he noted the priority of names he continued to use the specific name *constrictus* throughout the paper. In his discussion, however, he stated: "Per questo suo caratteristico aspetto, qualora avesse dovuto cambiar nome specifico, il distomide del Leared avrebbe potuto meritar quello *mistroides* (da *μυστροσ-ου* cucchiaio)." This statement was regarded by Stiles and Hassall (1908) as a renaming of *Distoma constrictum* Leared. Later Looss (1899) proposed the genus *Hapalotrema* for *Mesogonimus constrictus* (Leared) of Monticelli, basing his discussion of this form on material collected by him from the heart of "*Thalassochelys corticata*" at Abukir, Egypt. A comparison of the descriptions and figures given by Monticelli and by Looss, however, show certain differences which suggest that while the forms studied by them are unquestionably congeneric, they probably represent distinct species, and are not the same as, or congeneric with, the species described by Leared. In view of the foregoing, the following points must be considered: (1) The status of *D. constrictum* Leared and of the name *mistroides* Monticelli; (2) the status of the genus *Hapalotrema* Looss; and (3) the identity of *Mesogonimus constrictus* (Leared) of Monticelli and *Hapalotrema constrictum* (Leared) of Looss. The solution of these problems appears to the writer to be as follows:

1. Since *Distoma constrictum* Leared is a homonym it must be renamed, and since the name *mistroides* indicates an anatomical character (spoon-like shape of the body) of the species which Monticelli described as *Mesogonimus constrictus* and which does not apply to Leared's species, the specific name *mistroides* must apply to Monticelli's species. The writer, therefore, proposes for *D. constrictum* Leared the new name *Learedius europaeus.*

2. *Hapalotrema* Looss was proposed as a genus for *Mesogonimus constrictus* (Leared) of Monticelli and applies to that species and not to Leared's species, and since the specific name *mistroides* appears to be the valid name for Monticelli's form, the type of the genus is *Hapalotrema mistroides* (Monticelli, 1896) Stiles and Hassall, 1908 (syn. *Mesogonimus constrictus* (Leared) of Monticelli, 1896; misdetermination).

3. Neither Monticelli nor Looss gave any indication as to the extent of variation occurring in the specimens which they studied, and in view of this

lack of information one must assume that the drawings which they published are representative of the forms which they had before them. A comparison of these drawings shows differences in the number of testes and in the extent of vitellaria, and in body proportions which are as great as, or greater than, those occurring in species of other genera. Monticelli's figure shows 9 testes in the preovarial group and 16 in the postovarial group, whereas in Looss' figure there are 8 in the preovarial group and only 10 in the postovarial group. Monticelli's figure also shows distinctly that the vitellaria unite in the median field anterior to the preovarial group of testes and also posterior to the postovarial group, while in Looss' figure no such union is shown. In Monticelli's figure the oral sucker is of the same size as the acetabulum, while in Looss' figure the oral sucker is about one-third smaller than the acetabulum. There are also noticeable differences in the relative distances between the suckers in the two illustrations, but these may be due to variation in the amount of contraction or extension of the specimens drawn. In view of the disparity as given above the writer feels that for the time being Looss' form should be regarded as a distinct species and proposes for it the name *Hapalotrema loossi* (syn. *Hapalotrema constrictum* (Leared) of Looss, 1899, not *H. constrictum* (Leared) of Monticelli = *H. mistroides* (Monticelli).

Up to the present time the following genera have been included in the family Spirorchidae: *Spirorchis* MacCallum, 1918 (syn. *Proparorchis* Ward, 1921), *Henotosoma* Stunkard, 1922; *Haematotrema* Stunkard, 1922; *Hapalotrema* Looss, 1899; *Hapalorhynchus* Stunkard, 1922; *Vasotrema* Stunkard, 1926; *Unicaecum* Stunkard, 1926; *Spirhapalum* Ejsmont, 1927; *Diarmoschistorchis* Ejsmont, 1927; and *Tremarhynchus* Thapar, 1933. To this family are now added three additional genera, *Neospirorchis* n. g., *Amphiorchis* n. g., and *Learedius* n. g. Whether all of these genera should be regarded as valid is a matter of personal opinion. Ejsmont (1927) not only doubts the validity of some species assigned to certain of the above genera but of some of the genera as well. The present writer does not propose to go into the question of the validity of the species at the present time, but so far as the genera are concerned he does not regard *Henotosoma* Stunkard and *Haematotrema* Stunkard as sufficiently different from the genus *Spirorchis* to be considered distinct, the types of the genera, *Henotosoma haematobium* Stunkard and *Haematotrema parvum* Stunkard, becoming *Spirorchis haematobium*, (Stunkard) and *S. parvum* (Stunkard), respectively. *Tremarhynchus indicus*, as described by Thapar (1933), apparently does not differ sufficiently from *Hapalorhynchus gracilis* Stunkard to warrant its separation as a distinct genus, the differences being specific rather than generic; *T. indicus* Thapar, therefore, becomes *H. indicus* (Thapar).

The genera of Spirorchidae fall into two more or less well defined groups, one consisting of monostomatous forms and the other of distomatous forms. Ejsmont, however, has shown that evidence of transition occurs in some of the genera, a fact which makes it undesirable to regard the two groups as

subfamilies. In the genus *Diarmoschistorchis*, which was proposed for a monostomatous species, *Spirorchis blandingi* MacCallum (1926), the testes are arranged in two groups, one group preovarial and the other postovarial; this condition simulates that occurring in species of *Hapalotrema*, which are distomatous. The writer has had the opportunity of examining MacCallum's specimens of this species, and is inclined to regard it as an abberrant form not closely related to the distomatous species. The testes, 12 or 13 of which are preovarial and 3 postovarial, are arranged in a linear series as in the monostomatous species and not irregularly as in the distomatous species; the arrangement of the other organs is the same as in the genus *Spirorchis*. The relation of *Diarmoschistorchis blandingi*, therefore, to such genera as *Haplorchis*, *Amphiorchis*, and others of the distomatous group is questionable. The other example of transition between the two groups, which Ejsmont pointed out, is *Spirhapalum polesianum;* this is a distomatous form which does show definite evidence of transition, especially as regards the egg which is oval and contains a miracidium with eyespots as in the genus *Spirorchis*. Aside from the egg, *S. polesianum* might easily be regarded as congeneric with *Hapalotrema mistroides*, but in the latter species the egg is spindle-shaped and the miracidium is not provided with eyespots. Much might be said regarding the relationships of the genera and families of blood flukes, but such a discussion is not within the scope of this paper.

Key to the genera of the family Spirorchidae

1. Monostomatous forms 2
   Distomatous forms 5
2. Testes 2 or more 3
   Testis single and spiral 4
3. Testes preovarial . . . . *Spirorchis*
   Testes both preovarial and postovarial . . . . *Diarmoschistorchis*
4. Intestine consisting of a single cecum . . . . *Unicaecum*
   Intestine consisting of 2 branches uniting near equator of body and forming a common cecum as in the Schistosomatidae . . . . . *Neospirorchis*
5. Testes numerous, preovarial . . . . *Learedius*
   Testes numerous, or single, both preovarial and postovarial, or postovarial only 6
6. Testis single, postovarial; esophageal diverticula present . . . . . *Vasotrema*
   Testes 2 or more, preovarial and postovarial; esophageal diverticula absent 7
7. Testes numerous 8
   Testes 2 in number 9
8. Egg oval; miracidium with eyespots . . . . *Spirhapalum*
   Egg spindle-shaped; miracidium without eyespots . . . . *Hapalotrema*
9. Genital aperture dorsal, in front of anterior testis . . . . . . *Hapalorhynchus*
   Genital aperture ventral, posterior to anterior testis . . . . *Amphiorchis*

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ZOOLOGY.—*A new species of the nematode genus* Aphelenchoides *living in sugar cane.*[1] G. STEINER, Bureau of Plant Industry.

Aphelenchoides heterophallus n. sp. was observed in a piece of sugar cane stalk originating in Jamaica.[2] The rind of the cane was a normal green color; the axial portion, however, had a blackish discoloration probably caused by a fungus. It was in this latter portion that a pure culture of the new nematode species was found. *A. heterophallus* is a well characterized form, most closely related to certain species found in the mines of and associated with bark beetles of Europe and the Pacific Northwest. The present case may also involve some association with an insect (most probably a carrier relationship), although the piece of sugar cane stalk exhibited neither mines nor other traces of insects. The complete absence of saprophytic nematode species and of signs of decay seems to exclude the possibility that the infestation was picked up by contact with soil.

The thin cuticle is very obscurely annulated. The anteriorly convex head is well set off. Male and female tails differ in shape, that of the latter being conical and elongated (fig. 1B), and that of the former having a broad, obtuse base with a distinctly set off point (fig. 1D and E). The length of the female tail, however, is quite variable. The head is supported by a cuticu-

[1] Received December 19, 1933.
[2] Intercepted at the Port of Philadelphia, Pa. by inspector A. B. Wells of the Bureau of Plant Quarantine.

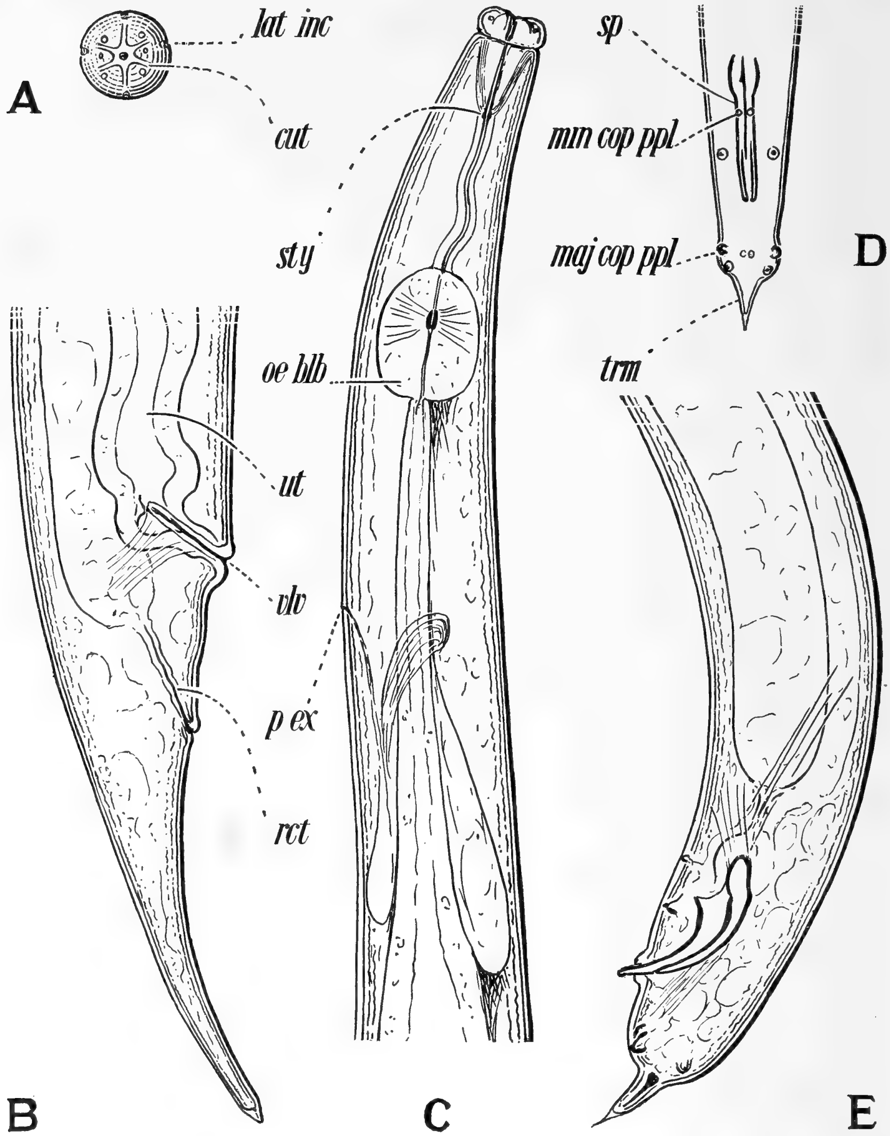

Fig. 1.—*Aphelenchoides heterophallus* n. sp. × about 1250. A, Top view of head; *lat inc*, lateral incisure; *cut*, cuticularized framework. B, Posterior portion of female; *ut*, uterus; *vlv*, vulva; *rct*, rectum. C, Anterior portion of body; *sty*, buccal stylet; *oe blb*, esophageal bulb; *p. ex*, excretary pore. D, Ventral view of tail of male; *sp*, spicula; *min cop ppl*, small copulatory papilla; *maj cop ppl*, large copulatory papilla; *trm*, terminal processus. E, Lateral view of tail of male.

larized framework which is star-shaped in front view (fig. 1A). The arrangement of the sense organs is that typical for the genus. In a front view of the head a rather remarkable lateral and medial incisure is seen on the periphery. The delicate buccal stylet has only a slight indication of basal knobs. The very large esophageal bulb, located about three spear-lengths behind the anterior end, is provided with small valvulae and rather reduced muscles. The rectum is about as long as the anal body diameter. Males and females are equally numerous.

The most characteristic feature of the female is the prominent vulva located near the anus (fig. 1B), the distance between vulva and anus being only about half the length of the tail. The single ovary is not reflexed. There is no posterior uterine branch.

In the male the terminal processus also varies somewhat in size and shape. The spicula are juxtaposed (fig. 1E) and of quite characteristic shape, though they still retain the outlines of typical *Aphelenchoides* spicula. There are two small and three large pairs of copulatory papillae (fig. 1D and E). The smaller ones are close to the ventromedial line, one pair being about level with the proximal third of the spicula in front of the anus, the other in about the middle of the tail. Of the three larger pairs the first is located a little caudad of the middle of the spicula, the second ventro, the third dorsosubmedial, close to the base of the obtuse portion of the tail.

		med. bulb	nrv. ring	70.		
female—	1.0	5.2	6.1	92.6	95.7	0.75 mm.
	.97	1.7	1.7	2.2	1.3	
				74.		
male—	1.3	6.3	7.1	M	97.5	0.71 mm.
	1.1	2.2	2.2	2.9	1.6	

DIAGNOSIS

Aphelenchoides with delicate, minutely knobbed stylet. Vulva prominent; distance from vulva to anus about one-half the length of tail or less. Male tail with broad, obtuse basal portion ending with a distinctly set-off finger-like processus. Male papillae as follows: A pair of small papillae subventral about level with the proximal third of the spicula; a similar pair also subventral in the middle of the tail; a pair of larger ones, ventrosubmedial, slightly caudad of the middle of the spicula; a second and third larger pair ventrosubmedial and dorsosubmedial respectively, at the base of the obtuse portion of the tail. Spicula juxtaposed, aphelenchoid.

Type host: Sugar cane.

Type locality: Jamaica.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

255TH MEETING

The 255th meeting of the Academy was held in the Auditorium of the National Museum at 4:45 P.M., on Thursday, November 16, 1933. About 150 persons were present. President GRIGGS introduced the Reverend Dr. G. LEMAITRE, professor of physics in the University of Louvain and lecturer at the Catholic University of America, who delivered an address on *The expanding universe.*

256TH MEETING

The 256th meeting of the ACADEMY was held in the Assembly Hall of the Cosmos Club on Thursday, January 18, 1934. Seventy five persons were present. Vice President H. L. CURTIS presided and introduced ROBERT F. GRIGGS, Professor of Botany, George Washington University, retiring President of the ACADEMY, who delivered an address on *The problems of Arctic vegetation.*

The 36th Annual Meeting of the ACADEMY was called to order by President R. F. GRIGGS, at 9:20 P.M., immediately after the 256th regular meeting. Thirty-six members were present. The minutes of the 35th Annual Meeting were read by the Recording Secretary and approved.

Annual reports of officers were presented as follows:

The corresponding secretary reported that on January 1, 1934, the membership consisted of 16 honorary members, 3 patrons, and 521 members, one of whom was a life member. The total membership was 540 members, of whom 378 reside in or near the District of Columbia, 136 in other parts of the continental United States, and 26 in foreign countries.

The members of the ACADEMY stood while the Secretary announced the following deaths:

OTIS F. BLACK	F. P. GORHAM
ARTHUR P. DAVIS	W. H. HOLMES
HARLAN W. FISK	ORMOND STONE

The Recording Secretary summarized the five public meetings of the ACADEMY, one of which was a joint meeting with the Medical Society.

The Treasurer reported that the receipts of the ACADEMY during the past year amounted to $4,983.81 including the return of investment of $50 and interest on investments of $993.06. The disbursements amounted to $5,195.30 including bills for the year 1932 totaling $413.79. The bank balance at the end of the year was $1,365.35. The investments of the ACADEMY comprise $6,337.50 in stocks, $6,758.87 in bonds, and $8,000.00 in real estate notes making a total of $21,096.37 computed on the basis of cost to the ACADEMY.

Doctor H. H. HARLAN, chairman of the board of auditors, reported examination and approval of the books and properties in the hands of the Treasurer, after which both reports were accepted.

The report of the Board of Editors was presented by the Senior Editor, HUGH L. DRYDEN. Volume 23 consisted of 77 original papers covering 588 pages and illustrated by 30 halftones and 78 line cuts. The total cost per printed page exclusive of reprints and of the cost of the new's service was

$5.50 as compared with $6.62 for 1932. The cost to the ACADEMY of supplying 50 free reprints of each article was $0.57 per page. A marked increase in the space devoted to scientific notes and news was made possible by a contract with Science Service operative during the year.

Doctor W. B. Bell, chairman of the board of tellers, reported the election of the following officers: *President,* L. B. TUCKERMAN; *non-resident Vice-Presidents,* E. C. ANDREWS and E. T. WHERRY; *Corresponding Secretary,* PAUL E. HOWE; *Recording Secretary,* CHARLES THOM; *Treasurer,* H. G. AVERS; *Managers for the term of three years ending January, 1937,* W. M. CORSE and J. E. GRAF.

The Corresponding Secretary read the list of members nominated for Vice-Presidents by the affiliated societies. Upon motion the entire list was unanimously elected as follows:

Philosophical Society, H. L. DRYDEN
Anthropological Society, MATTHEW W. STIRLING
Biological Society, CHAS. E. CHAMBLISS
Chemical Society, D. BREESE JONES
Entomological Society, HAROLD MORRISON
Geographic Society, FREDERICK V. COVILLE
Geological Society, C. N. FENNER
Medical Society, H. C. MACATEE
Historical Society, A. C. ALLEN
Botanical Society, CHARLOTTE ELLIOTT
Archaeological Society, WALTER HOUGH
Society of Foresters, SAMUEL B. DETWILER
Washington Engineers, PAUL C. WHITNEY
Electrical Engineers, E. C. CRITTENDEN
Mechanical Engineers, H. L. WHITTEMORE
Helminthological Society, G. STEINER
Bacteriological Society, N. R. SMITH
Military Engineers, C. H. BIRDSEYE
Radio Engineers, H. G. DORSEY

President GRIGGS appointed Past President L. H. ADAMS to escort President TUCKERMAN to the chair. After a short address, he declared the meeting adjourned.

CHARLES THOM, *Recording Secretary.*

BOTANICAL SOCIETY

246TH MEETING

The 246th regular meeting was held in the Assembly Hall of the Cosmos Club on January 3, 1933. President CHARLES BROOKS presided; attendance 150.

Brief notes and reviews: A. S. HITCHCOCK of the International Committee on Botanical Nomenclature reported that the new rules were practically finished in English and that translation into other languages would probably be completed by the end of 1933.

Program: W. A. ARCHER: *Botanical explorations in Choco Province, Colombia.*—Choco Province is about twice the size of New Hampshire with a low central area surrounded on all sides by mountains. The annual rainfall is approximately 457 inches. The population of some 60,000 consists of a few

scattered white people and the balance Indians of Choco stock and negroes. About 500 plant specimens were secured, including a large number of new species. Of the scant 40 economic plants obtained, several are new, indicating the need for further studies of the flora of the region.

247TH MEETING

The 247th meeting was held in the Assembly Hall of the Cosmos Club, February 7, 1933. President CHARLES BROOKS presided; attendance 55. FLORENCE E. MEIER and LEWIS B. LOCKWOOD were elected to membership.

Brief notes and reviews: W. A. WHITNEY reviewed a new *Dictionary of Colors* by Maerz and Paul, including more than 7,000 colors, which may be freely exposed to the light. DAVID GRIFFITHS exhibited a plant of the genus *Lachenalia* with decorative leaves and flowers. M. B. WAITE reported on two interesting conifers, *Torrya taxifolia* and *Juniperus barbadensis*, the latter growing at Wrightsville, North Carolina, 30 miles north of its previous northernmost station. H. R. FULTON exhibited a branch of satsuma orange bearing fruiting bodies of *Schizophyllum commune*.

Program: CHARLES THOM: *The arsenic fungi.*—The history and significance of the group of fungi capable of attacking insoluble arsenical substances and producing gases with a garlic odor and more or less toxicity, were developed along the lines established by Thom and Raper in Science **76** (1980): 548–550, December 9, 1932. The ubiquity of these species in relation to the general use of arsenic in excess in combatting insects was stressed as involving injury to certain crops and health hazards worthy of serious consideration. (*Author's abstract.*)

Discussed by Messers WHITNEY, WAITE, RAPER, THONE, and ROSE.

G. M. DARROW: *Short daily light periods the cause of the rest period and regional adaptation in strawberries.*—This was a report of experiments and observations covering the past ten years on the effect on varieties and species of short days during summer, and long days during winter, the relation of shortening days of fall to the rest period, the intensity of the rest period of different varieties, breaking the rest period by exposure to low temperatures and by increasing the daily light period, and the significance of this in breeding. (*Author's abstract.*)

248TH MEETING

The 248th meeting was held at Meridian Mansions Hotel, March 7, 1933. President CHARLES BROOKS presided, attendance 89.

Dinner was served at 7:00 o'clock. DAVID GRIFFITHS supplied extensive table decorations including Narcissus, Iris, and Lachenalia. During the meeting he pointed out the different varieties and explained a new method of forcing which had enabled him to secure the blooms within three to four weeks. DEAN H. ROSE outlined briefly various methods of preparing frozen fruits, of which the strawberries served at the dinner were an example.

Program: J. R. SWALLEN: *Yucatan as seen by a botanist.*

249TH MEETING

The 249th meeting was held in the Assembly Hall of the Cosmos Club, April 4, 1933, President CHARLES BROOKS presiding; attendance 109. JAMES M. PICKENS was elected to membership.

Brief notes and reviews: F. THONE exhibited four recently published botanical works, *Plant Sociology*, Braun-Blanquet; *Plant Ecology*, Weaver

and Clements; *Natural Gardens of North Carolina,* Wells; and *The Plant World in Florida,* Nehrling. C. A. LUDWIG showed graphs of the distribution of cowpea and hairy vetch seeds by weight classes. R. KENT BEATTIE called attention to the first two numbers of *Phytopathological Classics,* the first *Attempt at a dissertation on the diseases of plants* by Fabricus, published in 1774 and translated by Mrs. K. Ravn; and the second, *Observations on the rust of grains* by Fontana, published in 1767. H. B. HUMPHREY discussed the precipitation record for Washington, D. C., from January 1930 through March 1933, the record disclosing a net accumulated deficiency of 23.53 inches.

Program: D. H. ROSE: *Bruising and freezing injury of apples in storage and transit.*—Published in mimeographed form by the Bureau of Plant Industry.

CHARLES DRECHSLER: *The capturing of nematodes by fungi.*—Published in substance. THIS JOURNAL **23**: 138–141. 1933.

250TH MEETING

The 250th meeting was held in the Assembly Hall of the Cosmos Club, May 2, 1933, President CHARLES BROOKS presiding; attendance 44.

Brief notes and reviews: H. B. HUMPHREY exhibited 9 species of endemic violets. C. A. LUDWIG exhibited a specimen of quack grass (*Agropyron repens*) which had grown through the root of a sumac bush. A. S. HITCHCOCK requested information on the location of types of plants to be used in a central index of types which would be available to botanists.

Program: J. H. MARTIN: *Grohoma and other fake grains: their origin and exploitation.*—Grain crops are a favorite medium for exploiters. Poulard, Polish, Fulcaster and other wheats, hulless varieties of oats and barley, proso and Pearl millets have been exploited frequently. Grohoma, a new grain sorghum, has been exploited by several firms and individuals since 1929. It was claimed to have been originated by grafting a kafir bud on a stalk of sorgo. Extravagant and fraudulent claims were made for Grohoma in extensive seed selling campaigns. Efforts of the Department of Agriculture and State officials resulted in suppressing much of the fraudulent advertising and in greatly curtailing the sale of Grohoma seed at high prices. The fake grafting process on sorghums was detected. Exploiters attempted to retaliate against Department and State officials for exposing the fraud by using political and legal methods but were unsuccessful. (*Author's abstract.*)

Discussed by Messers RABER, SWINGLE, HITCHCOCK, and BRIERLY.

C. O. ERLANSON: *A resumé of potato investigations in Mexico and South America.*—The Bureau of Plant Industry sent out expeditions in 1931 and 1932 to obtain new varieties of potatoes for use in breeding new types resistant to the various virus diseases of this crop. Potato relatives, numbering about 150 species, are distributed from New Mexico and Arizona south through the mountains of Mexico, Central and South America. About 600 collections of tubers and seeds of potatoes and potato relatives were obtained from the two expeditions. This material is now being grown at several experiment stations where studies will be made as to the resistance to degeneration diseases of any promising types which develop.

Discussed by C. A. LUDWIG.

251ST MEETING

The 251st regular meeting was held in the Assembly Hall of the Cosmos Club October 3, 1933. President CHARLES BROOKS presided.

Program: J. B. KINCER: *Long-time temperature trends: Are the old fashioned winters gone?*—Attention was called to the remarkable sequences of years with supra-normal temperature, especially during the fall and winter seasons, which have occurred over eastern North America since 1876. Weather records for Washington, D. C., show that 18 of the last 21 winters have been warmer than normal, and that all of the last 13 have been mild; only 3 of the 25 fall seasons since 1907 have had sub-normal temperatures while 15 of the last 17 months, including September 1933, had plus departures from normal. The abnormally warm weather experienced in general for a long time past does not mean, however, that cold periods have been entirely absent. The records indicate that occasional brief spells of abnormally cool, or extremely cold, weather are characteristic of prevailingly high temperature trends. The cold winter of 1917–18 coming at a time when the long-time trend was running comparatively high was cited as an example, and also the fact that the lowest official temperature on record for the United States—66 degrees below zero—occurred in the Yellowstone National Park in February, 1933.

Discussed by W. A. TAYLOR and M. B. WAITE.

H. H. MCKINNEY: *Time of sexual reproduction in wheat as influenced by temperature and light.*—Shoot development and flower differentiation in the wheat plant are affected by temperature and length of day. Winter wheats are low-temperature short-day plants during leaf and tiller formation, and high-temperature, long-day plants during elongation and heading. The low temperature requirements for earliness in winter wheat can be met during the early stages of germination by exposing partly germinated seeds at 35–38° F. for 65 days. The treatment called iarovization by the Russians, and vernalization by the English, may be carried out in either darkness or light. By its means heading of wheat may be significantly advanced.

252ND MEETING

The 252nd regular meeting was held in the Assembly Hall of the Cosmos Club on November 7, 1933. President CHARLES BROOKS presided.

Program: W. W. DIEHL: *The lack of chlorosis in some sterility diseases of grasses.*—The effect upon certain grasses of a systemic infection produced by certain parasites recognized in the genera, *Myriogenospora, Dothichloë* and *Balansia* is to produce a partial or complete sterility, unaccompanied, however, by any chlorotic condition, since diseased plants and organs are of a normal green color. Dependent upon the particular combination of host and parasite there may be a dwarfing or an invigoration of the diseased plant. The examples which were chosen to illustrate these conditions were as follows: *Andropogon virginicus* infected by *Myriogenospora; Aristida glauca, Sacciolepis striata, Panicum clandestinum, and Sporobolus berteroanus* infected by *Dothichloë; Cenchrus echinatus* infected by *Balansia claviceps;* and *Danthonia* spp. infected by *Balansia Hypoxylon.* (*Author's abstract.*)

J. R. MAGNESS: *The functioning of fruit trees as influenced by moisture supply.*—When a portion of the root zone of apple trees reaches the wilting percentage, the daily period of stomatal opening becomes reduced. Under extreme water shortage, stomata fail to open at any time during the day. Rate of fruit growth is closely correlated with the moisture condition and stomatal behavior. When sufficient moisture becomes available following drought conditions, leaf function and fruit growth are apparently resumed

at a normal rate. Under conditions of water shortage, the starch-sugar ratio in bark and wood is modified, tissue from trees under moisture shortage containing more sugar and less starch than under ample moisture supply. Total carbohydrates manufactured as well as total starch in the tree are reduced by water shortage. Fruit bud formation apparently is increased by the water shortage associated with high soluble carbohydrate content in the tissues. (*Author's abstract.*)

Discussed by L. E. YOCUM and M. B. WAITE.

253RD MEETING

The 253rd regular meeting was held in the Assembly Hall of the Cosmos Club, December 5, 1933, President CHARLES BROOKS presiding.

Program: Address of retiring President CHARLES BROOKS: *After-harvest botany—Some botanical aspects of perishable food products.*—This address will be published in The Scientific Monthly.

33RD ANNUAL MEETING

The 33rd annual business meeting and election of officers was held following the adjournment of the 253rd meeting.

The recording secretary reported 8 regular meetings and one outing during the year. The annual dinner was held in March at Meridian Mansions. The average attendance at the regular meetings was 87. Thirteen new members were elected, two absent members reinstated, two active members placed on the non-resident list, and four members lost by resignation. Dr. J. A. FARIS died September 24th. The active membership is 213. Three members, W. H. EVANS, V. K. CHESTNUT, and W. W. EGGLESTON, who retired during the year, were elected to honorary membership.

The following officers were elected: *President,* NATHAN R. SMITH; *Vice-President,* W. W. DIEHL; *Recording Secretary,* FREEMAN WEISS; *Corresponding Secretary,* ANNA E. JENKINS; *Treasurer,* NELLIE W. NANCE; *nominated as Vice-President of the Washington Academy of Sciences,* CHARLOTTE ELLIOTT.

CHARLOTTE ELLIOTT, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

CWA aids American archaeology.—CWA archaeological projects in five states, under the guidance of the Smithsonian Institution, are yielding new data in American archaeology. An old Indian burying ground explored in Kern County, Calif., has revealed grave posts of extraordinary importance. The wooden posts may enable archaeologists to establish some definite dates, thus turning prehistory into dated history in California. The posts are of cedar or juniper wood. Old as they are, annual growth rings in the wood are well preserved. It is hoped that by comparing the rings with the long calendar of annual rings shown in California redwood trees, the years when the grave posts were cut and made can be determined. The California Indians whose age may be learned were buried with few possessions. The excavators have found 150 burials, wrapped in cloth and matting, in the graveyard.

CWA workers near Murphy, N. C., have excavated an Indian mound and

identified the site as a Cherokee village visited by the Spanish explorer De Soto. It is called "Guasili" in the Spanish records. Another Indian village which De Soto may have visited is being explored at Bradenton, Fla. European glass beads suggest that the Spanish gold-seeking expedition tarried there, and exchanged beads for information, hospitality, or supplies.

A large mound being explored by another CWA group in Macon, Ga., is proving far more extensive than had been expected. Near the top, the digging has disclosed evidence of European contact. More deeply buried are phases of aboriginal cultures, some belonging to historically known tribes. From pottery fragments, the archaeologists see indications that these Georgia Indians had contacts with tribes farther north.

In Tennessee, the CWA workers are still seeking to identify Indians who built the numerous mounds in Shiloh National Military Park.

Photographic map of Indian lands.—A huge airplane photographic map, 40 by 24 feet, of the Navajo and Zuni Indian lands in New Mexico, Arizona, and Utah has been contracted for by the Department of the Interior. It is to be used as a basis for the better regulation of grazing practises, which have already gone to severely damaging excess in many small areas and a few large ones.

Airplanes making the photographs will fly at an altitude of over 20,000 feet, taking more than 4,500 individual photographs with a special four-lens camera. The separate pictures will be fitted together into a single mosaic map. The total cost of the work will be about $77,000; but if the work were done by ground parties it would cost more than $500,000.

A new deal for ducks.—Secretary of Agriculture WALLACE, with the approval of President ROOSEVELT, has appointed a committee to outline a course of action under a proposed plan for enlarging areas on which game birds can be fed and bred. The first projects will be for the restoration of the feeding grounds of ducks and other migratory game birds, including the reflooding of unprofitable "reclaimed" swamp and lake lands, the renewal of natural food supplies, cover and nesting sites, and the protection of the birds from natural enemies and illegal hunters. Correlated with the lowland projects is a program of reversion to brush and timberland of upland areas in the submarginal agricultural class, giving cover for non-migratory upland game birds and mammals. These can be handled at least partly on a "game farming" basis by the landowners. The cost of the program, it is proposed, shall be met in part through a low Federal hunting license fee, together with a small tax on hunting ammunition.

Fish cultural survey of Puerto Rico.—On January 25 Dr. S. F. HILDEBRAND senior ichthyologist of the U. S. Bureau of Fisheries, sailed from Baltimore for Puerto Rico to conduct a survey of the fish cultural possibilities of the island.

On the occasion of his visit to the United States Mr. R. MENENDEZ RAMOS, Commissioner of the Department of Agriculture and Commerce of Puerto Rico, requested the assistance of the Bureau of Fisheries in assessing the possibilities of developing trout culture in the high mountain streams and in several reservoirs of the northern watershed on the island, as well as the possibility of propagating and stocking the lower reaches of the streams with other food and game fishes. The Puerto Rican Government is cooperating in the survey by defraying the field expense of the investigation, and the Bureau is furnishing the services of the investigator.

News Briefs

The third Arthur Lecture was given by Dr. Charles G. Abbot, secretary of the Smithsonian Institution, in the hall of the U. S. National Museum on the evening of February 26. The subject was, *How the sun warms the earth.*

The American Academy of Tropical Medicine was founded at a conference held at the National Academy of Sciences on February 5, under the auspices of the National Research Council. Dr. Theobald Smith was elected its first president.

The U. S. Public Health Service has received advices from Manchukuo indicating that the United Anti-Plague Commission has been re-established as a permanent organization.

Greater refractivity of the lower layers of the atmosphere during periods of profound calm may be due to the "settling to the bottom" of the heavier isotopes of oxygen, sorted out by differential gravitation, L. W. Tilton of the National Bureau of Standards, has suggested in a communication to *Nature.*

James A. Ford of the Smithsonian Institution has discovered a mound-builder dwelling site near Marksville, La., with clearly marked post-holes giving dimensions and general architectural plan. Though far from the traditional Hopewell country, it seems to belong to the Hopewell culture type.

Public attention was directed to a widespread incidence of measles by the U. S. Public Health Service, on February 7. Measles outbreaks seem to run in cycles of about two and one-half years, it was pointed out; and this is apparently the peak of a cycle.

Radio talks under the auspices of Science Service were broadcast over the network of the Columbia Broadcasting System, by F. A. Silcox, chief forester, U. S. Forestry Service, on January 31, and by Dr. Vincent du Vigneaud of the faculty of the George Washington University School of Medicine, on February 7.

A number of mallard ducks have been donated to the Office of National Parks, Buildings and Reservations of the U. S. Department of the Interior and placed on Roache's Run on the Mount Vernon Boulevard. It is believed that this will form the nucleus of a bird sanctuary at this point which will undoubtedly attract many Washington visitors. A report made February 9 says that the original 27 pairs planted at this point had attracted a considerable number of other ducks. The total number is now in excess of 250.

The Secretaries of the Interior and Agriculture each have appointed two men within their Departments as members of a committee of five, the fifth member being the chairman, Mr. Jacob Baker, to assemble and recommend lands to be acquired in connection with a program for the purchase of submarginal lands with $25,000,000 made available through the Public Works Administration.

On January 15 the five district officers in the United States having charge of State Park Emergency Conservation Work met in the office of assistant director Conrad L. Wirth of the Office of Public Parks, Buildings and Reservations, U. S. Department of the Interior, for the purpose of discussing

general organization plans and work to be carried on in State Park Emergency Conservation work camps during the third enrollment period. This period will start next April 1 and extend to March 31, 1935, provided Congress appropriates the necessary funds.

Dr. G. W. Wait, of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, broadcast a talk entitled *Electricity in the atmosphere* on January 30 from Station WMAL under the auspices of the Greater National Capital Committee of the Washington Board of Trade.

Personal Items

Capt. Albert W. Stevens, U. S. Army Air Corps, has been awarded the Franklin L. Burr prize of the National Geographic Society in recognition of his work on aerial photography, particularly his photograph from 20,000 feet altitude of the moon's shadow during the total solar eclipse of 1932.

Paul G. Redington, chief of the Bureau of Biological Survey and F. C. Lincoln, who is in charge of the Bureau's bird-banding work, attended the joint meeting of the Northeastern Bird-Banding Association and the Federation of the Bird Clubs of New England, held in Boston, on January 19.

O. J. Murie, Biological Survey field naturalist stationed at the Elk Refuge in Wyoming, is in Washington conferring with Bureau officials on matters pertaining to his studies of the elk of Jackson Hole, Wyo.

Assistant Director Harold C. Bryant, assistant to the superintendent of Yellowstone National Park Joseph Joffe, and Mr. David E. Madsen of the Wild Life Division, represented the Office of National Parks, Buildings, and Reservations, U. S. Department of the Interior, at the American Game Conference held in New York City the latter part of January. Former Director Horace M. Albright also attended. In connection with this conference a special meeting of the Commission on the Conservation of the Elk of Jackson Hole was held, at which Mr. Joffe was appointed secretary to succeed Mr. Ovid Butler.

W. E. Emley, chief of the organic and fibrous materials division of the National Bureau of Standards, addressed the Board of Directors of the General Federation of Women's Clubs in Washington on January 11, in regard to consumers' specifications for hosiery. Mr. Emley also addressed the annual meeting of the National Association of Dyers and Cleaners in Chicago on January 17 and presided at a meeting of the Research Committee of the U. S. Institute for Textile Research in Washington on January 20.

W. D. Appel, chief of the textile section of the National Bureau of Standards, attended a meeting of the shrinkage committee of the American Standards Association in New York on February 1. This committee is considering the adoption of an American standard for measuring the shrinkage of fabrics.

On January 2, Dr. Frederick A. Davidson, associate aquatic biologist of the Bureau of Fisheries, was appointed by the commissioner to serve as acting director of the Fisheries Biological Laboratory at Seattle, Wash., relieving Joseph A. Craig, who has been serving as director since October 7, 1931.

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This JOURNAL. the official organ of the Washington Academy of Sciences, publishes: (1) short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The JOURNAL is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years.

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JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. 24 APRIL 15, 1934 No. 4

BOTANY.—*The problem of arctic vegetation.*[1] ROBERT F. GRIGGS, George Washington University.

One of the most definite of the side lines which I expected to carry through when the National Geographic Society sent me to Katmai was a study of the vegetation of the region—that is of the normal vegetation outside the area devastated by the great eruption of 1912.

But when I tried to classify the vegetation on the ground as it would be done by an ecologist further south, I became confused and had to give it up. It was easy to segregate the plant societies in a few special situations like the strand and the dunes. But these were all habitats of minor importance, and after they had been considered the main body of the vegetation remained hopelessly confused. Five times upon returning to the States, I renewed the determination to master the problem on the next trip. And every time until the last I gave it up as beyond my power of generalization.

This may sound strange in view of the fact that many others before me have studied arctic vegetation and have published voluminous records of what they observed. I shall return to a brief consideration of the literature, but at this point I may say merely that earlier students had not, to my mind, solved the problem of dealing with arctic vegetation. All of them have attempted to treat arctic ecology from analogy with the ecology of temperate regions. But high latitudes are different from low latitudes and analogies break down. I felt that a new point of view was essential to effective treatment of the problem and until this was gained nothing could be accomplished.

DISTINCTION BETWEEN ARCTIC VEGETATION AND ARCTIC FLORA

I should, perhaps, explain the distinction drawn between arctic vegetation and the arctic flora. The student of a flora, a taxonomist,

[1] Address of the retiring president of the Washington Academy of Sciences delivered January 18, 1934. Received February 6, 1934.

is concerned primarily with the species which occur in a region, with the species as separate entities, while the student of vegetation, an ecologist, is concerned primarily with the relations of these species to each other and to their physical environment, as they grow together in the field. The taxonomist stands to the ecologist somewhat as does the nurseryman to the landscape gardener. The work of the taxonomist and the nurseryman must underlie any development of ecology or of landscaping. But as successful planting requires a great deal more than a knowledge of the nurseryman's materials, so an ecological treatment demands very much more than a knowledge of the flora of the area studied.

In the temperate zone vegetation is rather clearly segregated into more or less well-marked associations, like beech forests, oak forests, pine woods, swamps, and bogs. Each of these associations has a somewhat definite composition, and mention of a few plants at once conveys to one familiar with the country a picture of the whole association. Thus when you enter a pine woods hereabout you expect to find spotted pipsissewa and dewberries, but not maidenhair fern, jack-in-the-pulpit or Dutchman's breeches. Study of vegetation types has convinced us, moreover, that these associations are not accidental, but that they arise from causes to be found in the special requirements of the species present interacting with the different conditions of the various habitats.

When one goes to the arctic he naturally expects to find similar plant associations, but instead he meets a bewildering mixture of plants of all sorts jumbled together in seeming defiance of the principles of plant association learned in low latitudes. The criteria by which plant associations are distinguished further south break down in the arctic. In few of the different habitats can characteristic species be named, and most habitats are invaded with some measure of success by almost every species of the flora. The fact that two species happen to be associated in a given situation means nothing as to their habitat preferences—to the utter bewilderment of a botanist accustomed to finding one set of plants in oak forests and another in beech woods. Lacking plant associations in the sense of more or less organic societies with definite constituent species, the vegetation appears an indescriminate mixture of the species of the flora as though the plant cover of any situation depended merely on the seeds that happened by chance to fall thereon instead of on the fitness of the species represented for that particular habitat.

INDIFFERENCE OF ARCTIC PLANTS TO ALTITUDE

A special case of this sort of thing is the indifference of arctic plants to altitude. This has been noted by many observers and in many lands. Whereas in the south we find definite zones of vegetation with the alpine types limited to the highest mountains, nothing of the sort occurs in the arctic. There the sea cliffs and the mountain summits have practically the same flora.

A curious instance of the indifference of plants to altitude in the north, though in this case in a boreal rather than in an arctic country, has recently been brought to light in Newfoundland. There Fernald (1933) has found a large number of high-arctic species reaching their southern limits not on the mountains but on the coast near sea-level. Conversely a number of southern species such as *Schizaea pusilla* of the New Jersey pine barrens, and the orchids, *Habenaria psychodes, Calopogon puchellus, Cypripedium acaule,* and *Pogonia ophioglossoides*- together with *Rynchospora alba, Bartonia, Utricularia clandestina, Xyris* and others, which reach their northern limits in Newfoundland, are to be found not on the lowlands but only on the high tablelands of the interior. The high-arctic element confined to the coast makes an especially impressive showing since the arctic species already collected comprise 49½ per cent of the total flora of the Arctic Archipelago and Fernald thinks that their number would be considerably increased by further collecting.

But arctic vegetation like the arctic flora is similar all around the pole, and it has been described by many observers, especially in Scandinavia. It is instructive to observe the devices used by these writers in the attempt to characterize an indiscriminate vegetation. They fall in general into two categories. Either the accounts are abstractions too far removed from the actual plant cover, or they are merely particularized descriptions of individual patches of plants whose variations are neither in any way correlated with physical factors, nor of general application to other areas.

PRESENT PRACTICES IN DEALING WITH ARCTIC VEGETATION

The Upsala school, which adopts the second course, sets up more than one hundred "associations" to describe a vegetation where there are less than that number of common species. Thus Fries (1913) in northern Sweden lists fifteen lichen-rich heaths as follows: (1) Lichen-rich *Empetrum* association, (2) lichen-rich *Phyllodoce* association, (3) lichen-rich *Azalea* association, (4) lichen-rich *Andromeda tetragona* association, (5) lichen-rich *Andromeda hypnoides* association,

(6) lichen-rich *Salix herbacea* association, (7) liverwort-*Salix herbacea* association, (8) lichen-rich *Dryas octopetala* association, (9) lichen-rich *Diapensia lapponica* association, (10) lichen-rich *Juncus trifidus* association, (11) lichen-rich *Carex rigida-C. lagopina* association, (12) lichen-rich *Hierochloë alpina* association, (13) lichen-rich *Calamagrostis lapponica* association, (14) lichen-rich *Festuca ovina* association, (15) lichen-rich Forb association. Further it is to be observed that a number of the character plants given above appear also as character plants in several other associations, e.g. *Empetrum nigrum* appears in the moss-rich *Empetrum* heath, the *Empetrum*-rich lichen-birch forest, and the *Empetrum* high-moor. Moreover the subordinate plants in each of these associations include to a large extent the character plants of adjoining associations. *Empetrum nigrum* also appears in the plant lists of the following eighteen associations: (1) Heath-like lichen-birch woods, (2) *Myrtillus nigra*-rich lichen birch woods, (3) *Azalea*-rich lichen-birch woods, (4) *Carex rigida* lichen birch woods, (5) *Polytrichum*-rich lichen-birch woods, (6) lichen-rich *Betula nana* bushland, (7) lichen-rich *Diapensia lapponica* association, (8) lichen-rich *Juncus trifidus* association, (9) lichen-rich *Calamagrostis lapponica* association, (10) moss birch woods, (11) mossy *Betula nana* bushland, (12) mossy *Andromeda tetragona* association, (13) mossy *Calamagrostis lapponica* association, (14) *Geranium silvaticum*-rich meadow birch woods, (15) *Cirsium heterophyllum*-rich meadow-birch woods, (16) *Betula nana* high-moor, (17) *Salix glauca* high-moor, (18) *Rubus chamaemorus* high-moor. While it is true that *Empetrum* is probably the most nearly ubiquitous of all the species in the lower arctic regions, yet most of the other common species would make the same sort of a showing.

I must beg the reader's pardon for giving such a jumbled and repetitious list of names. But if left out, the real situation would be grasped only by those who took the trouble to look up the original. Nothing would have been easier for me at Katmai than to have given a similar list of a hundred or more "associations." But however useful such an analysis might be to the writer himself it did not seem to me that it would be very helpful to the ecological fraternity in general.

The difficulty of the problem may be readily visualized from a perusal of Ostenfeld's account of the botany of the Faeröes (1908), which, though lying at a comparatively low latitude, are essentially arctic in character. He works out a clear and logical classification, but he tells us (page 920) that it is "more abstract than in most other

countries and it will be necessary again and again to indicate the gradual transition from one association to another." These transitions (page 935) "recur with almost tiresome frequency and an accurately defined survey is almost impossible." (Page 920) "It will be understood that differences so slightly defined are difficult to maintain," and again (page 981) "The mosses as well as the higher plants convey the same impression, they are a very mixed and heterogeneous company."

VARIABLE HABITAT PREFERENCES OF ARCTIC PLANTS

From the literature also another aspect of the puzzle appeared; not only are the habitat preferences of arctic plants obscure but such as they are they vary from region to region, thus breaking down the few ideas on the subject I had been able to deduce at Katmai. In the "Flag" vegetation of Iceland, according to Hansen (1930), rock-dwelling alpine plants such as *Silene acaulis*, *Saxifraga oppositifolia*, and *Thalictrum alpinum* grow together with aquatics including *Subularia aquatica*, *Triglochin palustris*, and *Ranunculus reptans*—a mixture which passes my imagination even after my experiences at Katmai. Again the Arctic fireweed, *Epilobium latifolium*, which is confined to rock crevices and gravel bars in southern Alaska, in Greenland invades the ponds and pushes creeping runners two to three meters long out into water knee-deep (Rikli, 1910). A third illustration I quote from Simmons (1913), who reports (p. 145) "*Statice maritima*, a pronounced halophyte in the south becomes an inland and mountain plant in the north."

Arctic ecology fairly bristles with anomalies like these, the mere mention of which arouses one's desire to understand them. Probably many of them would be readily explained if they were attacked experimentally. Some day we shall have laboratories as well as field stations in the arctic where such problems may be solved.

DEFINITION OF TUNDRA

Not the least of the difficulties of dealing with arctic vegetation lies in the prevalent confusion as to what constitutes "tundra." Good writers use the term in two distinct senses, some with a geographic, some with a descriptive connotation. Thus the Standard Dictionary defines it as "A rolling treeless plain of Russia, Siberia, and the American arctic regions, covered with moss and at times very moist or marshy." The reason for this ambiguous definition probably lies in a natural desire to convey to persons who have never visited the

arctic some concrete idea of the appearance of the tundra. But the inevitable result has followed. The two meanings will not hold together. The arctic plains are by no means universally boggy, consequently some writers have fixed upon the geographic sense of the word and others upon the descriptive. Then the layman, unaware of the real situation, and endeavoring to gain some idea of the country, re-synthesizes the diverse conceptions and concludes that the whole arctic is a barren moss-covered morass, gaining his ideas of the character of the tundra from those who use the word in a descriptive sense and of its extent from those who use it in a geographic sense. This is the situation which Stefansson has endeavored to set right with his phrase "The friendly arctic" and by his prolonged efforts to portray the possibilities of reindeer and muskox culture in the north.

Clearly enough ambiguity cannot be tolerated in a scientific term. If tundra is to be retained its meaning must be fixed. But unfortunately both senses are thoroughly established in good usage. To Alaskans and to a certain extent to Canadians tundra is nearly synonymous with bog. The forest bogs of southeastern Alaska which differ little from the bogs of Oregon and Washington are called tundras by the people of the country. Such usage is not confined to common parlance but is to be found in scientific literature as well. Witness the following from Summerhayes and Elton's (1928, p. 264) account of Spitzbergen. "Tundra, defined as swamp or moorland, is quite absent from Spitzbergen." Nevertheless much of the "heath" described from Spitzbergen and other parts of the Atlantic province of the arctic is exactly the sort of vegetation which Alaskans would single out as tundra, and thus confusion creeps into the ranks even of those who use the word in a descriptive sense.

Now there are, to be sure, extensive areas of the tundra which are best described to a southerner as boggy, but the larger part of the arctic is arid, and the innermost subpolar areas are more arid than the outer transitional regions. Simmons (1913, p. 31) discussing the ecological conditions of the Arctic Archipelago says "The prominent and important factor I take its extreme dryness to be." The annual precipitation in all high arctic countries is less than 10 inches, a deficiency in rainfall which in lower latitudes invariably marks a desert. It should be pointed out however that much less rainfall is required to support a given type of vegetation in high latitudes than in low. There are several reasons: (1) Evaporation is less on account of lower temperature. (2) The water requirement of a given plant is proportional to the length of the growing season. (3) In parts of the arctic

fog and mist are so prevalent that measurements of collected rainfall do not give a correct idea of the humidity of the climate. (4) Thawing of snow and ground ice keeps poorly drained situations soggy throughout the summer with very little loss by runoff. But after all allowances are made for economy in the utilization of the scanty rainfall the essential fact remains that the arctic is predominantly an arid country and that furthermore the high arctic is more arid than the lower.

It was in the discussion of desert country that the term tundra was introduced to scientific literature by Middendorf (1864). Middendorf found the analog of tundra to be not bog but steppe and went into long and detailed comparisons of tundra and steppe. He found it indeed somewhat difficult to produce satisfactory differentiating characters between the two aside from the plant species concerned. He describes the Siberian tundra as the most extreme desert, "ödste Öde" (p. 736) and states that it is too dry to be compared with any terrain familiar to Europeans. Further, he specifically states that no peat develops in the "high tundra."

Middendorf had a very wide acquaintance with the tundra not only across Siberia but in Russia and Lapland as well. He clearly differentiates the "high tundra" or what we might call desert tundra from "low tundra" which he describes as grassy or boggy. Inasmuch as his account was not only the first, but remains to this day one of the best scientific studies of the tundra I believe that we would do well to follow him and use tundra in a geographic sense, applying it to all of the country of the treeless arctic.

BOUNDARIES OF THE ARCTIC

Another major difficulty lies in the lack of any general agreement as to the proper boundaries of the arctic. Before I could do anything with my own area at Katmai I had to decide whether it was arctic or temperate. Inasmuch as decision on this point would seem to be a prime requisite for further treatment of the subject, I will digress to consider it here.

The reason for the indecision as to the boundaries of the arctic lies partly in the lack of any comprehensive general treatment of arctic ecology and partly in a failure to recognize the fact that the arctic, like any other major vegetation zone, requires subdivision before it can be treated adequately. Explorers of high arctic countries are inclined to tell us that "real arctic conditions" or "true arctic vegetation" is limited to polar lands. It is natural enough for one familiar with Spitzbergen, north Greenland, or Ellesmere Land to

think northernmost Norway temperate by comparison. Thus we find Simmons (1913, p. 144) criticising Hooker's ideas of the Scandinavian arctic, saying "Even the northernmost part of the Scandinavian Peninsula is not an arctic but a temperate land."

There is no difference of opinion as to the facts at issue. No one doubts but that the flora of the arctic Archipelago is far more extreme than that of the North Cape. But if the two are to be assigned to different zones where should a line be drawn between them? From the extreme poverty of the plant life of the polar desert there is the most gradual transition to comparatively luxuriant vegetation like that of arctic Norway. Any boundary separating the two would have to be an entirely arbitrary affair.

It would be natural to call the transitional belt of more luxuriant vegetation surrounding the polar area subarctic. But unfortunately subarctic is well established in another application—to the circumpolar boreal coniferous forest. If we are to follow accepted usage and call the Hudsonian forest subarctic there is no alternative but to denominate as arctic all territory beyond the forest border.

There is really no need of attempting to move the term subarctic from the forest into the outermost belt of the arctic. If we recognize that North Greenland, the northern portion of the arctic Archipelago, and Spitzbergen are "high arctic" as is commonly done, it is a simple matter to term such countries as South Greenland, northern Scandinavia, and northern Alaska "low arctic," and that meets the problem just as well as though we should attempt to limit the "true arctic" to polar areas and reduce the outermost belt to subarctic.

IMPORTANCE OF THE ARCTIC TIMBER-LINE

It will be agreed that the arctic timber-line, the limit of coniferous forest, is one of the major vegetation boundaries of the earth. It is not only clearcut and easy to recognize, but it marks a transition important to life in its every aspect. Whether one thinks of the numerous plants of the undergrowth which find shelter in the forest but cannot grow beyond, of the birds and mammals which almost necessarily have different habits and different adaptations within and without the forest, or of the aboriginal cultures which develop in the possession of timber or in the lack of it—from every point of view the forest border is of fundamental importance. Even more significant from the human standpoint is the fact that the forest border marks approximately the northern limit of cereals and of all sorts of agricultural operations except reindeer grazing.

COMPARISON OF TREE LIMIT AND SUMMER TEMPERATURE

Recognizing that as one progresses toward the pole increasingly severe conditions are encountered and that in a general way the meagerness of polar life is due to the rigor of the climate, it is natural to seek a climatic transition at the timber-line. If one is not too particular about close coincidence of climatic and vegetational lines this may be done, for it may be observed that there is a rough parallelism between the edge of the forest and the July isotherm of 10°C. (50°F.).

But if one examines the case more closely, the discrepancies become somewhat disconcerting. On the Alaska peninsula the forest, which ends at Kodiak, is two hundred and fifty miles behind the isotherm which crosses at the Shumagin Islands. But in northeastern Alaska at about longitude 145° the forest has caught up and the two coincide. East of the Mackenzie near Cape Dalhousie the forest goes nearly one hundred and fifty miles beyond the isotherm. But on the west shore of Hudson's Bay it has fallen back again until it is three hundred and fifty miles below the isotherm. At Ungava Bay in northern Labrador, however, the forest again reaches forward until it is nearly four hundred miles beyond the isotherm which bends far to the south, nearly touching Newfoundland.

In western Eurasia as in western America the forest front, composed now of pines and now of spruces, again lags behind the isotherm by a hundred miles or more. This is true both in humid Norway and in arid Russia. In Siberia both isotherm and forest reach far northward, running probably as closely parallel as could be expected as far as the mouth of the Kolyma River, longitude 160°. But there as in eastern America the isotherm takes a sharp dip to the southward from about 69° to 52°, finally leaving Kamchatka at about 56° while the forest, here *Larix dahurica*, stretches nearly straight eastward along the upper course of the Anadyr River, coming to the sea nearly on the arctic circle at the head of the Gulf of Anadyr, more than 10° (700 miles) north of the isotherm.

The arctic vegetation zone thus defined by the forest front is a very irregular area. In the most southerly of the Aleutian Islands, which by any criterion are undoubtedly arctic in character, the boundary reaches down to latitude 51° 20′, which is a few miles further south than London. But at the mouth of the Khatanga River in the Tamir Peninsula it advances to 72° 50′, as far north as Upernivik, Greenland. This is a difference in latitude greater by about 100 miles than that from Miami, Florida to Montreal.

THE ARCTIC FOREST-FRONT NOT A CLIMATIC LINE

In an effort to harmonize temperature and tree-line various writers, Martin Vahl, Nordenskjold (1928), Brockmann-Jerosch (1919), and others have tried empirically to make up some formula that would fit the facts better than simple comparison with the isotherm. Such efforts are at best only guesses and there is little attempt to show any relation of cause and effect between the factors brought into the equations. Vahl, for example, has used the "formula[2] $v = a + bk$ where v represents the temperature of the warmest month and k that of the coldest month, and when a and b are *constants that have to be determined in each case*" i.e. are not constants at all but merely factors introduced, as a schoolboy would say, "to get the right answer." Such operations are not very helpful and may become vicious if, as sometimes happens, they impart a false appearance of mathematical precision to the statements made.

All are familiar with the fact that unexpected deviations from predictions often lead science into its most important advances. We need only recall the discovery of the two outer-most planets of our solar system by reason of the perturbations in the orbits of the others. It seems not at all unlikely that if we look behind the irregularities of the forest border instead of trying to fit them into climatic conditions, we may discover facts concerning climatic changes which will be of the first order of importance.

CLIMATIC CHANGES SUGGESTED BY ANOMALIES IN TIMBER LINE

An example of the possible fruitfulness of this point of view may be gained from consideration of the situation in northern Labrador where the forest extends 400 miles further north than apparently it should. This would suggest a recent climatic change—so recent that plant migrations have not yet adjusted the flora to the changed conditions. Now it so happens that the Danish excavations of the sites of the old Norse colonies in South Greenland exactly fit in with this inference from ecology (Hovgaard, 1925). The mediaeval Norse colonists lie buried in perpetually frozen ground. This of itself is surprising, for men do not often chop holes into ice to bury their dead. More significant, however, is the fact that the graves are grown through and through by the roots of trees. The roots even penetrated into the marrow of the bones. Now tree roots cannot grow into frozen soil. There is no question, therefore, but that within the last few hundred years South Greenland had a climate far milder than at

[2] Quoted from Nordenskjold (1928, p. 73). The italics are ours.

present, thus confirming the indication given by the forest. The graves, however, leave much to be desired as to dates and other details of the climatic change which they demonstrate. It is not at all impossible that a thorough study of timberline ecology around Ungava Bay might supply more specific information than is to be obtained from any other source.

I should add in passing that while the meteorologists accept, perforce, the evidence as to recent climatic change in Greenland they are not at all prepared to explain it.

Turning to the western side of the Continent now, the opinions of practically all explorers of Alaska are to the effect that here reverse changes are occurring and that the forest is advancing. This opinion, based on extensive but cursory observations of many men in many places, has been confirmed by detailed studies.

At Kodiak Griggs (1934) and Bowman (1934) brought out the following facts: (1) All the trees near the edge of the forest are young —less than 100 years old, whereas three miles back from the edge they exceed a meter in thickness and are over three hundred years old. (2) Many old trees now in a dense forest of younger growth are "open ground" trees with branches, now killed by overshading, clear to the base. (3) The rate of growth at the forest edge compares favorably with that of the same species, Sitka spruce, in southeastern Alaska many hundred miles behind the edge. (4) Records left by the early Russian settlers explicitly describe as treeless, areas now covered with heavy forest. (5) Peat from the bogs contains only a few scattering grains of spruce pollen such as would be blown a long distance, thus demonstrating that the present is the first forest that has occupied the ground since the beginning of the bogs i.e., since the glacial period.

Similar detailed studies, as yet unpublished, have been made by Robert Marshall around Bettles in northern Alaska, Lat. 67°, Long. 152°. These tell the same story. Here a different forest composed of white spruce is concerned. Mr Marshall tells me that the very last trees grow as fast and in every way appear as favorably situated as those many miles to the south of the forest limit and that the growth rate equals that of the same species in Eastern Canada.

PLANT RANGES SUGGESTIVE OF ACTIVE MIGRATIONS IN PROGRESS

The distribution of a number of arctic herbs, likewise, cannot be readily explained otherwise than on the hypothesis of active migration in progress. *Pedicularis capitata,* for example, is common and

characteristic of the *Empetrum* heaths of Kodiak, Lat. 58°. It is widely distributed in Asia as far as the Altai. From this region it stretches across Siberia and the American arctic through the Arctic Archipelago and enters Greenland on the northwest coast, Lat. 78°. While its abundance in the mild climate of Kodiak proves that its existence by no means requires the rigor of a polar climate, it is entirely absent from south Greenland, being restricted to the area immediately adjacent to the American arctic islands. Another wide ranging species which barely enters northwest Greenland is *Androsace septentrionalis*. In this connection it is interesting to observe that there are a dozen genera of plants which reach the Archipelago but do not cross to the milder shores of Greenland. Cases like this may not be significant however, for though migration seems altogether likely we have no knowledge of the actual fact. In almost all such cases the migration must be inferred. No actual study of the behavior of arctic species on the edges of their ranges has been made. It would be of great advantage to know about these matters instead of having to speculate. Methods of attacking such questions are available, (Griggs, 1914). Recognizing this problem, Porsild (1932), who has had more experience with arctic vegetation than any one else, remarks concerning some unsuccessful experiments of his, "I hope that the enumerated experiments with native Greenland plants will show that plant dispersals and migrations so willingly and so liberally assumed in every paper of plant geography may be quite different in nature itself."

The advancing forest is in fact almost the only case of active migration that has been worked out. Not everyone will be inclined at first to agree with me that the timberline constitutes the proper boundary of the arctic, but I believe that if anyone who doubts my thesis will try to replace the timber line by some other vegetation line, he will find himself in difficulty at once.

DIFFICULTY OF CHARACTERIZING THE ARCTIC FLORISTICALLY

The fact is that it is difficult to characterize, much less to define, the arctic by the plants that grow there. Plants confined to the arctic are surprisingly few in number. That is, there are few species, and there is not a single genus, confined to the arctic.[3] Moreover the species endemic in the arctic are not among its most characteristic plants.

[3] Of the grass genus *Pleuropogon* listed by Hooker as endemic in the arctic two species have since been discovered in west America, one in Oregon, the other in California, on the lowlands as well as in the mountains. The original species, *P. sabinei*, remains, however, one of the most characteristic of high arctic species.

Almost all arctic species, if species be taken in a broad sense, go well down into the temperate zone. Indeed, all but 150 of the 762 arctic species recognized by Hooker (1861, p. 258), "advance south of parallel 40° north."

The floristic characteristics of the arctic are chiefly negative, due to the absence from northern lands of species occurring at lower latitudes. Thus the flora of the Aleutian region includes about 350 species of seed plants and that of arctic Siberia about 400, but the arctic Archipelago has only 204 (Simmons, 1913), and many of these reach only the southern islands, while north Greenland has only about 125 species (Ostenfeld, 1926). Even so it would be easy to characterize the arctic floras if it were the important species that drop out. But the species which fail to go far north are generally those which are already scarce further south. The situation will be clear from a consideration of the plants of the extreme north where, if anywhere, definite arctic species should prevail. In extreme north Greenland, north of 83 degrees of latitude, only three flowering plants grow: The opposite-leaved saxifrage, *Saxifraga oppositifolia;* the arctic poppy, *Papaver nudicaule;* and a grass *Alopecurus alpinus.* The first two are classified by Ostenfeld as low arctic. They occur in every arctic province. Both are important members of the Katmai flora 1800 miles further south and the poppy extends to Colorado while the saxifrage reaches Vermont. Only Alopecurus can be described as high arctic and even it occurs in north Russia which barely enters the arctic vegetation zone.

On Smith Sound, several hundred miles further south but still almost 1000 miles above the arctic circle in Latitude 78°–79°, Ekblaw (1919) lists the six commonest plants as follows: the opposite-leaved saxifrage, *Saxifraga oppositifolia,* blue grass, *Poa pratensis,* arctic poppy, *Papaver nudicaule, Cerastium alpinum, Dryas integrifolia,* and *Cassiope tetragona.* It will be observed that only the two subarctic members of the extreme high arctic trio given above are here included and that our familiar Kentucky bluegrass is substituted for *Alopecurus.* Of the others, *Cerastium alpinum* is common to all arctic districts and is classed as low arctic by Ostenfeld. *Dryas integrifolia* is more limited in distribution but is also low arctic, leaving *Cassiope tetragona* as the sole type prevailingly characteristic of high arctic. But it occurs also far down into Labrador and Alaska.

Another way of approaching the problem is by considering the whole flora. Of the 125 species known from north Greenland above 76°, 11 according to Ostenfeld are subarctic, 59 low arctic, and 55

high arctic. of the species prevailingly high arctic 43 occur also in some low arctic region, Alaska, Scandinavia, Iceland, or Russia, or at low arctic stations in Greenland. Of the twelve species remaining which are confined to the high arctic, half belong to the "critical" genera *Taraxacum, Poa, Draba,* and *Potentilla.* A seventh, *Braya Thorildwulfii,* is a segregate from the widespread *B. purpurescens.* There remain *Pleuropogon sabinei, Deschampsia arctica, Ranunculus sabinei, Hesperis palasii,* and *Minuartia Rossii.* Only two of these twelve are even mentioned in Ekblaw's general account of the vegetation; one of the Taraxacums is mentioned merely because it is endemic and *Pleuropogon* is reported as growing "in a few of the shallow ponds." Thus the high arctic can be characterized floristically only by using species of minor importance in the vegetation. A number of high arctic species are, indeed, high arctic in one region only. The same is true in perhaps even greater degree in the low arctic.

LACK OF STRUCTURAL PECULIARITIES IN ARCTIC PLANTS

Because the plants of extreme polar habitats are all dwarfed and held close to the ground, there is a popular idea that arctic plants are possessed of some special anatomical peculiarities fitting them for the conditions in which they live. This is not the case. On this point Holm (1924, p. 81 B) speaks as follows:

> "As far as concerns the structure of arctic species it has been shown in the preceding pages that no morphological structure seems absolutely characteristic of these; they share the same development of their floral and vegetative organs with their southern allied species; they exhibit exactly the same method of vegetative reproduction as these and are in many cases not of such dwarfed stature as frequently described *******. There is thus no morphological character by which arctic and alpine species may be defined and we must therefore consider them from other points of view when the question arises to distinguish them."

ECOLOGICAL CHARACTER OF THE ARCTIC

Altogether the arctic can be characterized rather better ecologically than any other way. This is true in spite of the difficulties of arctic ecology. The prevalent vegetation type of the high arctic is open fellfield, nearly bare, rocky ground most nearly analogous to talus slopes with us. The only closed associations of any great extent are heaths dominated by *Cassiope tetragona* or by mosses, especially by *Rhacomitrium lanuginosum,* the famous "Grimmia heaths." Closed grassland is absent or restricted to very favorable situations which are best considered as oases of low arctic vegetation advanced beyond the general limit of that zone. The plants are perennial, annuals being

absent or almost so. All plants are held strictly to the ground, often rising only an inch above the general level. Bogs are formed by plants other than *Sphagnum*. Ponds are devoid of flowering plants or nearly so. This, however, is not a hard and fast rule, for while there are no aquatic flowering plants in Spitzbergen (Summerhayes and Elton, 1928, p. 265), both *Batrachium trichophyllum* and *Hippurus vulgaris* occur in north Greenland.

In the low arctic, fellfield is restricted to exposed and unfavorable situations. The heaths are dominated by *Empetrum* rather than by *Cassiope*. The most favorable habitats are occupied by grassland usually with bushes and scrub of willow, birch, or alder. The bogs may consist largely of *Sphagnum,* though that moss is of much less importance than in the boreal region to the southward.

A number of aquatics penetrate into the outer portion of the arctic zone, including, besides *Hippurus* and *Batrachium,* several species of *Potomogeton, Utricularia, Myriophyllum, Menyanthes, Callitriche,* and others.

CAUSES OF THE INDISCRIMINATE CHARACTER OF ARCTIC VEGETATION

These various considerations as to definitions, boundaries, and characterizations were no part of my original plan of study, but as I have shown it was necessary to go into them before I could undertake the problem which confronted me at the outset: Namely, the reason for the indiscriminate character of the vegetation at Katmai. Finally we are ready to undertake consideration of that problem.

The nearest analogs of tundra in temperate vegetation all belong close to the pioneer stage. The highest stages reached in the low arctic of Alaska are the poplar woods and the alder grassland. Back in the forest the poplar woods are paralleled by the cottonwood thickets that come up on new gravel bars along rivers, and something very similar to the alder grassland develops on avalanche tracks, where frequent disturbance prohibits the growth of climax forest.

A good share of the tundra is what we should call boggy, and in a country where bogs are to be found chiefly encircling and invading ponds, it is easy to see again that bogs stand close to the pioneer stage. The fellfield of the extreme north, which most nearly resembles talus slopes with us is still younger in the ecological scale. In the case of the two associations first mentioned, the river bar woodland and the avalanche track, the analogy with the arctic is rather good. If the same were true with bog and talus slope there would have been

little difficulty in working out the vegetation of Katmai. But with them the analogies are useful only insofar as they may serve in a feeble way to give one who has never seen the arctic some idea of the physical conditions of the habitats concerned. It is questionable indeed whether the attempt to draw analogies in these cases does not do more harm than good, for the differences between the arctic and the temperate types are more significant than their resemblances.

With us soggy, undrained bogs and loose, open talus slopes are so different in every way that we cannot imagine any difficulty in distinguishing them. Not so in the arctic. Neither bog nor fellfield has a distinctive flora, for most of the commonest and most characteristic of arctic plants spread promiscuously not only over bog and fellfield but over all habitats of intermediate dryness as well. And since this series, which includes the heaths, occupies the greater part of many arctic countries, herein lies the problem of arctic vegetation.

RESEMBLANCES OF ARCTIC AND RUDERAL VEGETATION

So long as I tried to solve this problem of arctic ecology by comparison with the native vegetation down here I found it impossible to proceed. Finally, however, I came to see the trouble. These northern vegetation types stand lower in the plant succession than any of the natural associations of the south. When I began to compare them with the ephemeral weed vegetation of cultivated fields a comprehension of arctic ecology began at once to dawn on me.

Go out to one of the numerous real estate developments where they have made over the landscape recently and try to classify the weeds that appear. Cataloguing the plants over several such developments, you will make a long list of familiar weeds. Now try to classify them as to habitat preference and their association with each other. You will make little progress, for the weed cover of new ground varies indefinably from place to place. The weeds, with some wellknown exceptions, have no associations. The population of any area depends much more on the kinds of seeds that happen to fall thereon than on fitness of the species present for that particular habitat.

SIMILARITY OF FELLFIELD AND PLOWLAND

One of the most evident resemblances, and perhaps one of the most significant, between fallow fields and high tundra is in the large amount of mineral soil exposed to colonization, and the further north one goes the more bare ground there is. On the fellfield the plants are spotted here and there with so much space between that a picture

of the habitat looks like a bed of shingle and the inconspicuous plants are hardly noticed except upon close inspection. This eliminates one of the most important of the ecological factors of lower latitudes. There is no struggle for room.

On the high tundra most of the plants are entirely out of touch with their neighbors. There is always plenty of free space for new plants. Thus while in the south nearly all plants have continually to wrest their living so to speak out of the very mouths of others which would take it if strong enough, in the far north the struggle for existence consists entirely of passive endurance of the rigors of the climate.

A second point of resemblance between tundra and plowland lies in the relatively small amount of humus commonly present in both. As everyone knows, one of the chief problems of agriculture is the loss of organic matter consequent upon cultivation and the ensuing wash. Fields cut out of the virgin forest soon lose the heavy coat of leaf mold which had been built up through ages of primeval conditions. Thereafter their soil approaches nearer and nearer to a mass of inorganic detritus unless organic matter is artificially added by green manures or similar means. This of itself favors the development of the species we know as weeds over the humus-loving natives originally in possession, (Croxton, 1928). These weeds both ecologically and floristically resemble arctic plants. In the arctic the formation of humus and peat either in thick layers or in small floccules is at a minimum.

Pedologists would call arctic soil very young, if they were willing to admit that the rock detritus which covers the ground in high arctic countries constitutes a soil at all. Presumably this juvenile, or better infantile, condition of the soil is due to an unfavorable climate which prevents the development of a proper soil. One would like to be able to discuss this problem in more detail but present knowledge does not permit. It is not impossible that it might have important implications.

Arctic ground is almost everywhere poor in nitrogen. This is generally attributed to the effect of low temperatures on the activity of nitrogen-fixing bacteria, but no thorough study of the matter seems to have been undertaken. The deficiency in nitrogen is so important that cliffs manured by nesting birds support a vegetation notably more luxuriant than occurs elsewhere. The arctic "barren grounds" might perhaps be "made to blossom like the rose" by the application of fertilizer.

A third and most important similarity of tundra to farmland lies

in the unstable condition of the soil. As a means of stirring up the ground and uprooting plants nothing but the plow can compare with the rigors of the arctic climate. The violence of heave and throw in daily freezing and thawing have been commented on by many writers. Another factor of importance has been brought to light by Johansen (1924, p. 26). He ascribes the bare spots on the tundra largely to disturbance by running water from melting snow and to slumping away of the ground after melting of ground ice. The plants which remain are those which happen to be favorably situated to escape such accidents. Thus tundra and field are alike in that on neither is vegetation allowed to grow for long before it is uprooted and destroyed.

If undisturbed the ruderal associations of cultivated fields and new ground soon pass into definite old field associations characteristic of the particular vegetation province concerned; white birches in New England, pines in the southern coastal plain. It is only by repeated plowing that the ruderal stage is maintained. In the north the necessary disturbance is supplied by Nature herself.

On account of the vicissitudes of freezing and thawing adjacent patches of tundra may be of very different age. While freshly denuded areas are conspicuous, as the years pass they gradually fade into the general tundra thereby introducing another element into the confusion of an explorer without detailed knowledge of the history of the areas observed.

HOMOLOGIES OF ARCTIC HEATH AND BOG

In a field the open stage wherein the soil is still largely unoccupied, which is comparable with the fellfield of the North, quickly passes into a closed "association" in which competition is keen and destructive as every gardener knows. In the extreme high arctic this open stage is permanent and succession does not go beyond the fell field.

In more favorable localities the vegetation spreads out and occupies the whole ground forming heath or bog. These are homologous with the second stage in the revegetation of a field. In the field the vegetation of this second stage may be even more erratic in composition than in the initial stage because the first pioneers consist exclusively of the species able to come up at once and they may arrive well ahead of the general weed population. In parts of the coastal plain for example, crab-grass, *Syntherisma sanguinalis*, always appears first. Following this in the second stage is a diverse assemblage made up of any one of a number of species or any mixture of them depending on the seeds that happen to be most available.

Because the ground is covered, the second stage may appear to be closed association, but this is a false appearance for such areas lack the essential character of truly closed associations in which each species present has some special fitness for the conditions of the habitat and all lacking such fitness are excluded by the intensity of the competition. If the term association as applied to vegetation means anything beyond mere physical propinquity it is clear that vegetation in this stage does not constitute proper associations at all.

This is the condition of the protean heaths and bogs at Katmai wherein the plants did not keep their places and so baffled a would-be classifier. Lack of the close-drawn competition which determines membership in associations higher in the succession explains both the apparent lack of habitat preferences in the most characteristic species, and of the infinite variation in the composition of the plant cover.

It may be needless to adduce further evidence that the tundra is in fact in the ruderal condition beyond that with which this essay is prefaced, but I shall cite one additional illustration showing how the irregularities in the distribution of arctic plants correspond with the vagaries in the occurrence of weeds. Three Greenland nunataks have been described by Warming (1888, p. 84–86). Their combined flora numbered 54 vascular plants, but no more than 27 occurred on any one of the three, and only two species were common to all three mountains. Clearly most of the 54 species, if once established, would thrive on any of these nunataks. The explanation here, as in the field, is that the flora of each is due to the accidents of immigration rather that to special fitness, and that colonization has not been completed.

The essentially unstable ecological condition of the tundra thus runs into and fits in with the instability of a higher order discussed above, namely the floristic irregularities which suggest that active migration of arctic species is still in full swing.

WEEDS NATIVE TO THE ARCTIC

I have said also that the ruderal character of arctic vegetation is floristic as well as ecologic. There is no time here to go into such an analysis of the arctic flora as would be necessary adequately to develop that fact. A brief summary with a few examples will illustrate my point.

The usual conception of arctic plants is that when they come south at all they are confined to high mountains. It will probably surprise many to learn that there are fewer species native above the arctic

circle which in their southern extensions are confined to alpine situations than of those which we know as weeds of cultivated ground. Long ago Hooker (1861, p. 277) pointed out:

"Of the plants found north of the arctic circle very few are absolutely or almost confined to frigid latitudes (only 50 out of 762 are so); the remainder, so far as their southern distribution is concerned, may be referred to two classes; one consisting of plants widely diffused over the plains of northern Europe, Asia, and America of which there are upwards of 500; the other of plants more or less confined to the alps of these countries, and still more southern regions of which there are only about 200."

To illustrate I cite a few familiar plants of fields and other new habitats which are native to the arctic, though some of them have come to us only as introductions from northern Europe. In this connection Porsild's (1932) paper on *Alien plants and apophytes of Greenland* is most instructive.

One of the worst of our weed invaders from Europe is sheep sorrel, *Rumex acetosella*. This is native in Greenland and is abundant in the untouched natural vegetation as far north as Disco, Lat. 70°. Dr. C. O. Erlanson tells me that the Greenland plant is in all respects closely similar to our weed.[4]

Toad rush, *Juncus bufonius*, a cosmopolitan weed which with us frequents roadsides and other open places, goes far north reaching 67° 49′ in Greenland, occurring there "in places which preclude human introduction." (Porsild, 1932.)

Horsetail, *Equisetum arvense*, which though unable to compete with more rapidly reproducing annual herbs for the occupation of cultivated fields, is fundamentally similar to a weed in that it is confined to new ground and is supplanted whenever species beyond the pioneer stage can take hold. With us it is restricted to such places as sand bars and road embankments. At Katmai it dominated the ashflats for a time after the eruption, coming through ash blankets too thick for other plants to penetrate. It goes to the far north reaching Spitzbergen and the north coast of Greenland, Lat. 83°.

Chickweed, *Stellaria media*, one of the most widespread and ubiquitous of weeds occurs generally in arctic as well as temperate countries. In Greenland it enters natural vegetation uninfluenced by human occupancy, yet it is considered certainly introduced. In arctic Norway, however, it is believed primeval. (Jesson and Lind 1923, Holmboe, 1906.) Its ability to enter the native vegetation of the arctic

[4] This does not accord with Porsild's published accounts. Erlanson, however, is more familiar with the temperate plant than is Porsild.

really gives clearer testimony as to the ruderal character of that vegetation than if it were native. This is clear from a consideration of its habitats with us. Here it is strictly an ephemeral weed unable to hold on in any permanent stabilized plant cover.

Rhode Island bent grass, *Agrostis canina,* is native to the arctic Archipelago, Greenland, and arctic Europe—but not at all to Rhode Island.

Similarly, Kentucky bluegrass, which as detailed above goes to the far north, is not believed to be indigenous in the northeastern United States. H. M. Raup (1934) discovered, however, that it grows in extensive pure stands in the subarctic meadows of the Mackenzie.

Our common winter cress, *Barbarea vulgaris,* likewise is native from Lake Superior northwestward into Alaska and Arctic Europe, but comes to us here as an introduced weed.

Plantago lanceolata is given by the Canadian Arctic Expedition (Johansen, 1924, p. 41 C.) as one of the characteristic plants of the uninhabited American arctic coast. It is also in arctic Europe where, however, Norman regards it as introduced. Hereabout it is one of our worst weeds.

Ranunculus acris, one of the commonest introduced weeds in our territory, is native and abundant in Arctic Norway and in South Greenland.

Polygonum aviculare, the little smartweed which everywhere edges into well-trodden paths in this country, or a close relative (there has been a recent redefinition here) is native in arctic Scandinavia, Iceland, and Greenland as far north as 70°.

Cardamine pratensis, which in the United States is native northward, but escaped southward, is indigenous throughout Greenland up to 76° as well as in Scandinavia.

Yarrow, *Achillea millefolium* and var. *nigrescens* (Fernald 1925, p. 269), is common on the tundra of the uninhabited country of the Alaska peninsula. Whether the native Alaskan plant is the same species as ours is disputed, but our common weed is indigenous to Scandinavia and Iceland. In Greenland it is replaced by the native arctic American form.

Anthoxanthum odoratum, the sweet-smelling vernal grass which comes up in waste places everywhere hereabout, is common in Scandinavia, Iceland, and South Greenland. In the latter place, however, it is believed to have been introduced by the old Norse colonists.

Epilobium angustifolium, the fireweed whose ephemeral character in this region is attested by its common name, is one of the most

characteristic of arctic plants, occurring in all low arctic districts and ascending to 70° in Greenland.

CONCLUSION

In short every feature of arctic vegetation, the anomalies in the geographical distribution of arctic species, the occurrence of many species in all sorts of habitats, and their apparent indifference to the diverse conditions thereof, the lack of definiteness to the composition of the plant cover in any particular habitat, the physical instability of the ground itself, the general ruderal character of arctic vegetation, the large number of our weeds which are native to the arctic—all these testify to an instability in arctic vegetation very different from the relatively stable plant formations of the temperate zone.

Each of the items contributing to the belief that arctic vegetation remains in a state of flux goes to indicate that the plants of the arctic, individually and collectively, are still far from equilibrium with their environment. This conclusion has far-reaching consequences.

First, combined with the demonstrated active migration of the Alaskan forest into the arctic, it gives definite support to the supposition that vegetation there has not yet recovered from the glacial period but is still in process of active readjustment.

Second, a science of arctic ecology cannot be built up on the assumption that the place and mode of occurrence of a plant give reliable indications of its optimum habitat. As this is one of the central theses upon which the ecology of the temperate zone has been built up, it is clear that arctic ecology must be worked out on an entirely different basis.

If the study of arctic ecology be approached from a dynamic rather than from a static and merely descriptive point of view, if instead of attempting to fit arctic vegetation into a supposedly stable climate, we try to work out the great movements of vegetation that are in progress, there lies open to the investigator a rich field which bids fair to throw much light on many features of our environment and its history that have an importance far beyond the immediate problems concerned.

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PHYSICAL GEOGRAPHY.—*Saline peat profiles of Puerto Rico.*[1] A. P. DACHNOWSKI-STOKES and RAY C. ROBERTS, Bureau of Chemistry and Soils.

The source of organic matter found in salt and brackish waters of the sea and the question of its abundance, specific nature, and function either in relation to the nutrition of marine bacterial and animal life, to the formation of coal, oil, and petroleum, or to practical agriculture, presents a number of highly important problems. Much information has been published showing the development of swamp forests of mangrove and other halophytic plant communities, but the most significant results of vegetation at work, namely, the characteristic features of organic accumulations and the phases bearing upon past conditions, have scarcely been considered.

The opportunity for the following article arose through field work carried on in Puerto Rico in connection with a survey for the U. S.

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Bureau of Chemistry and Soils with the cooperation of Dr. J. A. Bonnet, Chief of the Soils Division, of the Insular Experiment Station of Puerto Rico. Vertical cross sections believed to be representative of coastal swamps and salt marshes in northern and eastern parts of the island were collected by the junior author and the Station's surveyors. The former also made the determinations of soluble salts contained in the samples.[2] The descriptions of the peat profiles and the general discussion regarding them were contributed by the senior author. A specific aim has been that of basing the study upon the point of view set forth in a recent book dealing with a new system of classifying American peat deposits.[3]

Puerto Rico is an island well within the tropical zone in the Atlantic waters. It is approximately 182 km. (113 miles) long and 66 km. (41 miles) wide and includes an area of about 8,900 square kilometers (3,425 square miles). The island is largely mountainous and primarily of volcanic origin. It has been described as a portion of a chain of mountains under water, the summits of which reach an altitude of 1,350 m. (4,429 feet). Other summits of the range form the other islands which with Puerto Rico make up the group known as the Greater Antilles. A scientific survey of the region is in progress by cooperating institutions. Studies on the geology and physiography of Puerto Rico will be found in the publications issued by the New York Academy of Sciences[4] and the New York Botanical Garden.[5] A valuable descriptive account of the plant ecology of Puerto Rico and certain phytogeographic relations of the vegetation have been given by Gleason and Cook,[6] while information as to the climate and soils of the island may be obtained from the reports of the United States Weather Bureau and the Bureau of Chemistry and Soils.[7]

CHARACTERISTICS OF MANGROVE PEAT

On the coastal plain of the east side of the island are found numerous parcels of tidal mangrove swamps that grow in the water of the open bays and the open ocean where wave action is characteristic of the more exposed shores. The red mangrove (*Rhizophora mangle*

[2] The authors are indebted to Mr. E. H. BAILEY of this Bureau for the hydrogen-ion determinations on the air-dried samples.

[3] DACHNOWSKI-STOKES, A. P., and AUER, V. *American peat deposits.* In Handbuch der Moorkunde, vol. 7. Gebr. Borntraeger, Berlin. 1933.

[4] Sci. Surv. Puerto Rico I–VI. 1923–1926.

[5] BRITTON, N. L. and WOLCOTT, G. N. *Puerto Rico and the Virgin Islands.* Naturalists' guide to Americas, 700–705. 1926.

[6] Sci. Surv. Puerto Rico VII. 1927.

[7] DORSEY, C. W., MESMER L., and CAINE T. A. *Soil Survey from Arecibo to Ponce, P. R.* Field Oper. Bureau Soils, 1902: 793–839. 1903.

L.) is usually the pioneer species. This characteristic shrubby evergreen tree is widely distributed on tropical coasts and is the first to appear in the open water offshore. It extends farthest into salt water where it makes a dense growth and builds up islands of peat that are occupied by it alone. Colonies of impenetrable thickets, separated by tortuous channels of tidal salt water, push steadily seaward the margin of the swamp, gradually forming broad expanses that extend over hundreds of acres and are related chiefly to the gradient of the shore, shape of the sea floor, and the depth of salt water.

In the formation of new peat land the prominent adaptational peculiarities of the red mangrove are the specialized roots that arise from branches, grow down vertically as an interlacing tangle of stout pithy roots and together with numerous fine rootlets become anchored in the underlying soil. This dense network of roots and rootlets retards greatly the movement of sea water; it retains any decaying fallen leaves and twigs of the trees and any suspended organic matter and floating particles of silt or clay that may be carried by the water. Thus a type of peat profile is developed bringing ultimately the level of the layer to that of high tide.

Ensenada Honda type. In vertical cross section this type of profile represents one continuous layer of mangrove peat. The characteristics stated below were observed on a monolithic sample collected about 2 km. east of Ensenada Honda. It illustrates the development of a long coastal area of peat facing the waters of the ocean and connected with mangrove swamps most of which are under salt water and extend from the coast to the foothills. The morphological features of the profile may be described as follows:

Mangrove peat: 0 to 101.6 cm. brown to reddish-brown, coarse but firm fibrous peat, consisting chiefly of a porous, interlacing network of fine rootlets, yellowish-brown in color, brittle when dry, crumbling into small particles. Embedded in the tangle of rootlets are relatively small quantities of dark colored, finely divided organic sediments carried by tides and waves of sea water. A prominent feature is considerable amounts of stout roots of mangrove, the pith of which is in varying states of decomposition. The whole profile section is indistinctly differentiated, free from woody fragments and plant remains of secondary species, contains little mineral material, and is but feebly altered by soil making processes; it is the product of the roots and rootlets from a pure stand of mangrove. Soluble salts are present in the entire profile in amounts ranging between 3 and $5\frac{1}{2}$ per cent and the reaction of the air-dried material is strongly acid (pH 4.3–4.6). The thickness of the layer varies in places from 1 to $1\frac{1}{2}$ m. and rests abruptly on coarse white sand of unknown depth.

Many of the coastal mangrove swamps are cut for charcoal and

fuel, and serve as an important source of income. They re-establish themselves easily under natural conditions and should be used along newly built embankments as a means of preventing the wash of waves and undermining.

PEAT PROFILE FORMATION IN LAGOONS

On the north shore of Puerto Rico there are many places that are free from effective wind and wave action, but where salt water flows inland by tidal movement and produces saline conditions. The sheltered bays, estuaries, and great lagoons east of San Juan are of this nature. The shallow sea waters favor deposition of organic ooze, over and around which grows a halophytic vegetation showing transitions from saline to brackish waters and a succession of plant communities from shore lines fringed with littoral swamp forest of mangroves to marshes of cattail, rushes, and sawgrass toward the landward side. The mangrove swamps occur in strips bordering on quiet salt water in direct connection with the sea.

In general several species of mangrove compose the swamp forest. Of these the great bulk are red mangrove and to a less extent the black mangrove (*Avicennia nitida* L.). Other species such as *Laguncularia racemosa* and *Conocarpus erectus,* with an undergrowth of smaller shrubs and herbaceous plants are relatively more abundant landward. The presence of secondary species generally indicates an interference with the penetration of tidal salt water and the tendency of rains or fresh water streams to dilute periodically the salinity of the groundwater.

Along the shore at sufficient depths to preclude agitation by currents and waves, the bottom is covered with soft, black organic ooze. The formation of this residue appears to be partly a result of the action of bacteria in the salt water. By decomposing the remains of marine plants and animals a layer is formed that can be designated as sedimentary peat because of its similarity in origin and probably in chemical composition[8] to the sedimentary peat found in fresh water lakes and ponds. The thickness of the marine layer varies considerably but in some protected localities the mud-like residue is present in great abundance. Its decomposition is sufficiently slow to indicate that the constituents are altered anaerobically to a very small extent after their deposition. The various processes that might produce such beds of fine organic material, and preserve them as marine sediments,

[8] Trask, P. D., and Hammar, H. E. *Some relation of the organic constituents of sediments to the formation of petroleum.* Abstract in this Journal 23: 568. 1933.

have not received much consideration as yet. Some significant conclusions, however, may be drawn from the fact that the content of organic matter is consistently large and that its deposition is under saline conditions below effective wave action. For purposes of comparison the following profile is of interest.

Martin Peña type. The chief distinguishing feature of this profile is the fact that it is composed of two layers, markedly different in texture and composition. It consists typically of a surface layer of fibrous mangrove peat and an underlying layer of marine sedimentary peat. The profile was collected about 1½ km. east of Martin Peña railroad station from an area of mangrove swamp that represents an old channel-like depression and connected at one time Lake San Jose with the Harbor of San Juan. Much of the swamp forest has been cut-over for fuel; its surface is under water at sea level, and the entrance of tide water causes saline conditions some distance in the interior portion. A detailed study of the profile brings out the following:

Mangrove peat: 0 to 28 cm.; thin surface cover of black, sticky organic tidal ooze containing an occasional mollusk shell; the sediment varies in thickness from 5 mm. to 1.5 cm. Below it is reddish-brown, coarsely fibrous, matted mangrove peat which consists of a tangle of yellowish colored fine rootlets and large reddish-brown pithy aerial and lateral roots of mangrove (species of *Rhizophora* and *Avicennia*) embedded in black, finely divided organic residue. The material contains about 3 per cent of soluble salts and has a moderately acid reaction (pH 5.6).

28 to 61 cm.; finely fibered, very dark brown to mottled, more or less firm mangrove peat; it consists of a large proportion of black organic residue held in a meshwork of fine yellowish rootlets and is penetrated by a few stout, branching pithy roots in varying states of decomposition. The material is saline and acid (pH 5.1).

Sedimentary peat: 61 to 92 cm.; grayish-black, soft, oozy mixture composed chiefly of organic residue of the size of colloidal particles, together with gray colored fine rootlets. The layer is penetrated by a few pithy roots of mangrove; it becomes dense and hard when dry and breaks with smooth fractures. The content of soluble salts varies between 3 and 3½ per cent and the reaction is moderately acid (pH 5.6).

At a depth ranging from 1 to 1½ m., the underlying mineral soil is bluish green to gray plastic clay.

SALINIZATION OF A PEAT AREA

On the coastal shore of the island, between Arecibo and Barceloneta a line of consolidated sand dunes and limestone hills form a pronounced ridge. It separates from the near-by ocean an extensive level marsh nearly 13 km. long and from 1 to 1½ km. wide, known locally as Caño Tiburones. The natural outlet of the marsh is at the western end but numerous ditches and canals intended to drain it

have facilitated the entrance of salt water. Much of the surface of the marsh is at or below sea level and the natural vegetation indicates that in some places it is influenced by the denser salt water while in other parts the soil water is brackish or nearly fresh because of its slow diffusion.

Where the vegetation is still in a natural condition, Cook and Gleason[9] report that it consists of almost pure stands of cattail (*Typha angustifolia* L.) and sawgrass (*Mariscus jamaicensis* [Crantz] Britton), while at wider intervals are small patches of reed (*Phragmites communis* L.) and isolated thickets of shrubs. The vegetation changes more or less abruptly toward the western end into continuous masses of ferns (*Acrostichum aureum* L.) and still farther west into mangrove swamps where the salinity is increased by the entrance of the tides.

Ecologists are still uninformed as to the details of the origin and history of this marsh. The evidence of the surface vegetation as to the factors that operated during past periods is very slight, and there is reason to believe that the development of the marsh might be due perhaps to a progressive submergence of the coast. Since the composition and appearance of any vertical peat section depends primarily on the plant remains caused by a preponderance of species and by the successional trends of the vegetation, a detailed study of a profile should reveal any changes in natural conditions.

Caño Tiburones type. The profile described below was collected from the eastern part of the Caño Tiburones marsh, about 15 km. east of Arecibo. Its distinguishing features display two layers of peat in a reversed sequence of which the lower material is coarsely fibrous peat, developed under marsh conditions influenced by brackish water, while the upper layer is markedly dense and heavy in texture and represents conditions of nearly fresh water and a rising water level.

Sedimentary muck: 0 to 26 cm.; under cultivation; the material at the surface develops a black, granular muck, more or less mineralized; it contains bits of fine rootlets from crops (sugar cane) and shows channels of burrowing insects and worms. Downward it continues into sticky plastic sedimentary peat of heavy texture, dense, compact and hard when dry, tending to break into angular cloddy aggregates that later disintegrate into loose granules. The cultivated material is neutral in reaction (pH 7.3).

Tule peat: 26 to 58 cm.; black, stringy fibrous peat consisting mainly of soft, partly decomposed vertical stems and the rootstocks of tule (*Scirpus* sp., *Eleocharis* sp. and others), embedded in sticky plastic organic residue derived from secondary herbaceous plants. The material contains very small

[9] Cook, M. T., and Gleason, H. A. *Ecological survey of the flora of Puerto Rico.* Journ. Dept. of Agri. P. R. **12**: 1–139. *Illus.* 1928.

amounts of soluble salts, is slightly acid in reaction (pH 5.9) and shows a tendency to compaction and hardening when dry.

58 to 63 cm.; band of dark gray clayey mineral material probably due to flood waters; it is mottled with black organic residue and channeled vertically with partly decomposed, flattened culms of tule sedges (*Scirpus* sp.); the material is moderately saline and acid in reaction.

63 to 90 cm.; coarse stringy-fibrous tule peat, very dark brown to black, consisting largely of vertical, partly decomposed, more or less flattened stems of tule (*Scirpus* sp.) in a matrix of plastic amorphous organic residue. No visible alterations have taken place in the material during the period of time it has been buried by the mineral sediments. The content of soluble salts is fairly high, and the reaction is strongly acid (pH 4.2).

The thickness of the layer extends to a depth of $1\frac{1}{2}$ m. below the surface and the underlying mineral material is a bluish-gray, plastic clay.

It is apparent that Caño Tiburones first developed as a marsh characterized by fresh or brackish water in which tall-stemmed rushes (*Scirpus* sp.) were dominant and persisted in great abundance as the pioneer plant community. The profile section also indicates a sudden inflow of erosion water that carried with it large quantities of clayey sediments. Flooding, that may be attributed to a period of very moist climatic conditions,[10] or else subsidence, appears to have continued down to recent times. The change brought about a stand of water so nearly fresh that aquatic vegetation, forming sedimentary peat, replaced the tule marsh. The vegetation dominating at the present time is associated in places with saline conditions due to the entrance of tide water, but no particular part of it has, as yet, contributed to the development of fibrous peat.

SUMMARY

A brief discussion has been given of the more important characteristic features of three peat profiles that are representative of coastal shore conditions of Puerto Rico. These profiles from the tropics are members of a major group that includes two regional subdivisions, namely salt marshes such as exist along the open bays and estuaries of northern coastal states, and mangrove swamp forests and tidal marshes of tropical coasts and islands. To this maritime group of peat land the name halotrophic has been applied, to designate the fact that profile development is related to salt water or brackish water by the effective activity of plant communities associated in a successional trend. The peat materials are of a distinctive nature; they promise a basis for paleontological correlations and they may be significant in indicating the character of source beds of coal and

[10] *Reports of Second Conference on Cycles: Records of climatic cycles in peat deposits.* Carnegie Institution Washington, 55–64. 1929.

oil, accumulating in brackish and salt water, on or near ocean shore conditions.

PALEOBOTANY.—*A pine from the Potomac Eocene.*[1] EDWARD W. BERRY, Johns Hopkins University.

The Eocene of Maryland and Virginia comprises an older Aquia and a younger Nanjemoy formation collectively known as the Pamunkey Group, and the best general account of the geology and contained faunas is that by Clark and Martin, published in 1901.[2] Aside from undetermined and probably undeterminable drift wood in these marine beds I know of no terrestrial plants having been recorded from these deposits except the two nominal varieties of fruits described by Hollick in the volume above mentioned,[3] and referred to the form genus *Carpolithus* without any suggestions as to their probable botanical affinity. These are said to have come from the Woodstock stage, the uppermost of the two stages into which the Nanjemay formation was divided. It is these same forms in all probability which were noted by Ruffin in the last century in one of the earliest American papers on fossil plants,[4] since these objects are not of great rarity, although no one has attempted to discover their botanical affinity.

During the past summer Dr. W. Gardner Lynn of the Johns Hopkins University collected an excellently preserved cone of a new species of *Pinus* from an outcrop of the Aquia formation at Belvedere Beach on the Virginia bank of the Potomac, near the type locality of the Aquia formation. This may be appropriately named *Pinus lynni* n. sp. and described as far as the material permits as follows.

Pinus lynni n. sp.

Fig. 1

Cone thoroughly lignified and much compressed, somewhat macerated at both the apex and base. The part preserved measures 9.5 centimeters in length, 3.5 centimeters in width, and about 1.5 centimeters in thickness, so that in life it was relatively slender. That it was mature is indicated by the fact that it must have been shed or blown from the parent tree and was sufficiently dried to have been buoyant enough to have been floated into this marine basin of sedimentation. The faint impression of the seeds on the cone scales and the absence of any traces of seeds also indicates that these had already been shed. Scales triangular in profile, flat basally and somewhat thickened distad, the rhomboidal face being about 1.2 to 1.5 centimeters wide by 7 or 8 millimeters high with a prominent central transverse boss or

[1] Received Dec. 16, 1933.

[2] CLARK, W. B., and MARTIN, G. C. Md. Geol. Survey, Eocene, 1901.

[3] HOLLICK, A. Idem, p. 258, *pl. 64, figs. 11, 12.*

[4] RUFFIN, EDMUND. Amer. Journ. Sci. **9**: 127–129. 1850.

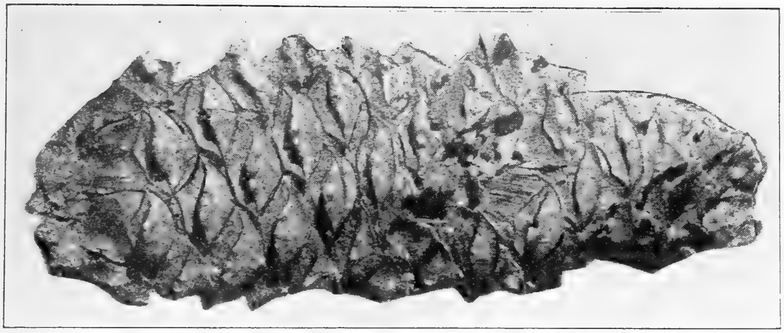

Fig. 1. *Pinus lynni* Berry ×1. Eocene, Belvedere Beach, Va.

umbo crowned with a central conical point, which does not appear to have been extended, but may have been abraded before fossilization.

Among the cones of existing North American species, this Eocene form shows resemblances in the size and proportions of the cone as a whole and of the individual cone scales to the three southeastern species *Pinus taeda* Linné, *Pinus elliottii* Engelmann, and *Pinus caribaea* Morelet. I suppose that too much reliance cannot be placed on resemblances of what, after all, are superficial features, but I give them for what they may be worth. That these resemblances are really objective is indicated by the fact that if the specimen had not actually been dug out of Aqui sediments I should have regarded it of Pleistocene age in spite of the fact that the lignification is more advanced than is usual in material of Pleistocene age.

Although *Pinus* is a reasonably ancient geological type and characteristic cones are found in this region in the late Lower Cretaceous (Patapsco formation) as well as in corresponding horizons in Europe, none have been encountered in the middle Atlantic states in the long interval between the Upper Cretaceous and the Pleistocene.

Pinus is, of course, present in western North America and on the other north temperate continents during the Eocene, Oligocene and Miocene, but is usually represented by woods or impressions of the foliage and actual cones are relatively rare.

Comparisons with described fossil cones afford nothing of pertinent interest. I assume, from the character of the cone scales and the resemblance to the existing species mentioned above that the present fossil belongs in the Pitch pine section of the genus.

The present occurrence is of great interest as it gives a hint at least of the character of the vegetation which clothed the shores of this region in early Eocene time, its essentially temperate character and the contrast which it suggests between this region and that of the shores of the Mississippi Gulf embayment where the very extensive known flora contained so many immigrants from more southern latitudes.[5]

[5] BERRY, E. W. U. S. Geol. Survey Prof. Paper 156. 1930.

PALEOBOTANY.—*Pliocene in the Cuenca Basin of Ecuador.*[1] EDWARD W. BERRY, Johns Hopkins University.

In 1932 Dr. George Sheppard of Guayaquil, Ecuador, transmitted to the U. S. National Museum, a small collection of freshwater invertebrates from two localities near the towns of Biblian and Paccha in the Cuenca Basin of southern Ecuador.

This was described by Marshall and Bowles[2] who enumerated 3 gastropods and 2 lamellibranchs—all new, which suggested comparisons with the so-called Pebas molluscan fauna from eastern Peru[3] of probably Pliocene age.

Recently I received from Dr. Roy E. Dickerson, Chief Geologist of the Atlantic Refining Company, two small collections which he made in the Cuenca Basin of Ecuador in 1927. These, although small, are of considerable interest. The first of these comes from an outcrop on the road from Biblian to Cuenca in the Azogues valley, where there is a good exposure of what Wolf many years ago noticed and referred to as "Arsenisca de Azogues."[4] The exact locality is along the Biblian-Cuenca road on the right side of the Rio Azogues, 16 kilometers south of the town of Biblian and 3 or 4 kilometers above the juncture of the southerly flowing Rio Azogues with the northerly flowing Rio Gualuabamba to form the easterly flowing Rio Paute.

The second locality is 3.1 kilometers southeast of Biblian in the Azogues valley and on the left side of the valley. The material from the latter locality is a compact, somewhat bituminous, neutral gray (K in Goldman and Merwin's color chart for sediments) shale which has the appearance of being a devitrified volcanic ash. No tests have been made to determine whether or not it is a true bentonite. I have not found any certainly determined plant fragments in this shale, but it does contain numerous cyprinodont fish scales, one of which is figured in the present paper. One of these is shown in Fig. 1 and is seen to be nearly circular with concentric growth lines and the usual longitudinal grooves on the anterior half. It is typically cycloid and may represent the same species of fish as that described by White (see infra) from the Loja Basin.

The material from the southernmost locality, first mentioned above is of two sorts—a whitish or light gray paper shale with plant remains

[1] Received Dec. 16, 1933.

[2] MARSHALL, W. B., and BOWLES, E. O. *New freshwater Mollusks from Ecuador.* U. S. Natl. Mus. Proc. **82**: art. 5. 1932.

[3] For a summary of the literature on Pebas see GARDNER, J. A. THIS JOURNAL **17**: 505–509. 1927.

[4] WOLF, T. *Viajes cientificos por la Republica del Ecuador-Relacion de un viaje geognostico por la Provincia del Azuay*, pp. 55–56. 1879.

and a slightly darker and more silty material with molluscan remains, which latter have caused more or less calcareous cementation.

The molluscan remains comprise a single specimen, doubtfully identified with *Potamolithoides biblianus* Marshall,[5] and a large number of specimens of a freshwater gastropod, which Mr. Marshall

Fig. 1. Cyprinodont fish scale.
Fig. 2. Leaflet of *Macrolobium tenuifolium* Englehardt.

states (letter of November 25, 1933) represents a new genus resembling *Gyrotonia* and other Streptomatidae of the southern United States. The paper shales contain fish-scales like those from the previous locality and many fragmentary impressions of plants. Only one of these is sufficiently complete to permit of identification and this proves to be a leaflet of *Macrolobium tenuifolium* Engelhardt[6] described originally from Loja, Ecuador. This specimen is shown in Fig. 2. In this connection it is pertinent to call attention to the small cyprinodont fish described by White[7] from the Loja deposits as *Carrionellus diumortinus* gen. et sp. nov. The present scales are somewhat larger than White had, but he mentions one specimen which indicated a fish twice the size of his complete specimens.

I discussed the Loja flora in 1925 and concluded that it represented a late Tertiary, and very probably a Pliocene assemblage, preserved in water laid sediments, largely volcanic ashes and at a lower altitude than that at which its existing representatives are now found.[8] More

[5] MARSHALL and BOWLES. Op. cit. p. 4, *pl. 1, figs. 1–3.*
[6] ENGELHARDT, H. Abb. Senck. Naturf. Gesell., Bd. **19**: 20, *pl. 2, fig. 17.* 1895.
[7] WHITE, E. I. Ann. Mag. Nat. Hist. ser. 9, **20**: 519–522. 1927.
[8] BERRY, E. W. Johns Hopkins University Studies in Geology No. **10**: 79–136, *2 figs., 6 pls.* 1929.

recently through the kind cooperation of Professor Clodoveo Carrion of Loja I have received material from a total of 18 localities in the Loja Basin scattered from the nudo of Cajanuma at the southern end to a locality 6 kilometers north of Loja.

Similar late Tertiary deposits have a considerable areal extent in the tributary valleys of the Rio Catamayo east and south of the town of Malacatos which is 27 kilometers south of the town of Loja. Engelhardt, in the paper already cited, recorded similar plant-bearing material from Tablayacu in the valley of the Rio Jubones, north of the nudo of Acayana.

The present occurrences in the Cuenca Basin demonstrate the presence of similar continental deposits a considerable distance farther north than was hitherto known, so that now we have actual records of the presence of such deposits over a distance of at least 170 kilometers from Biblian on the north to Malacatos on the south. Whether all these represent the reworked remnants of a single great volcanic eruption in Pliocene times and whether the resulting sediments once formed a continuous deposit is not known. Some of the deposits in the Loja basin are horizontal and in any event were formerly more extensive than they are now. All are undoubtedly of approximately the same age. The fossil plants in the Loja basin occur at altitudes between 7000 and 7300 ft., those in the Cuenca basin at an altitude of about 8000 ft. Both are now in the temperate altitudinal zone, whereas the fossil plants are mostly meosphytic types of the tropics and indicate not only a much lower altitude at the time they were living, but also a better distributed rainfall than that of the present in the Cuenca and Loja basins.

In considering the correlation of these inter-Andean deposits with those of Pebas in eastern Peru, attention should be called to the Pliocene fossil plants which have been described from the Rio Aguaytia in eastern Peru from beds which are probably a part of the same formation as those containing the so-called Pebas molluscan fuana, since apparently malacologists never read geological or paleobotanical papers. This small but exceedingly interesting flora[9] seems clearly to be of Pliocene age and contains several species which are also present in the Loja Basin.

[9] Berry, E. W. Johns Hopkins University Studies in Geology No. **6**: 163–182, *pls. 1, 2.* 1925.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

ANTHROPOLOGICAL SOCIETY

The Anthropological Society of Washington at its annual meeting held on January 16, 1934, elected the following officers for the ensuing year: *President*, MATTHEW W. STIRLING; *Vice-president*, FRANK H. H. ROBERTS, JR.; *Secretary*, FRANK M. SETZLER; *Treasurer*, HENRY B. COLLINS, JR.; *Vice-President of the Washington Academy of Sciences*, MATTHEW W. STIRLING; *Members of the Board of Managers*, BIREN BONNERJEA, GEORGE S. DUNCAN, HERBERT W. KRIEGER, WILLIAM DUNCAN STRONG.

The following is a report of the membership and activities of the Society since the annual meeting held on January 17, 1933.

Membership:	
Life members	3
Active members	46
Associate members	6
Honorary members	22
Corresponding members	22
Total	99
Deceased:	
Active members	1
Honorary members	1
Total	2
Resigned:	
Active members	3
Associate members	3
Total	6
New Members: Active	2

The Society lost through death the following members: *Honorary:* Prof. W. H. HOLMES, one of the founders of the Society and a past president; *active:* Captain ROBERT R. BENNETT.

Members elected during the year were: Mrs. MARGARET WELPLEY and the Honorable Dr. PEDRO M. ARCAYA, Minister of Venezuela.

The financial statement (Treasurer's report) is as follows:

Funds invested in Perpetual Building Ass'n		$1114.06
21 shares Washington Sanitary Improvement Co., par value $10 per share		210.00
2 shares Washington Sanitary Housing Co., par value $100 per share		200.00
Cash in bank		246.04
Total		$1770.10
Bills outstanding:		
To American Anthropological Ass'n	$60.00	
To printer	3.75	
Total	$63.75	63.75
Net Balance		$1706.35

Papers presented before regular meetings of the Society were as follows:

January 17, 1933, 643rd regular meeting, *The probable route of DeSoto through the Southeastern States*, by Dr. JOHN R. SWANTON, ethnologist, Bureau of American Ethnology.

February 21, 1933, 644th regular meeting, *Folk-lore in some languages of northern India,* by Dr. BIREN BONNERJEA of the Foreign Mission School, Catholic University.

March 21, 1933, 645th regular meeting, *Daily life of the James Bay Cree,* by Dr. JOHN M. COOPER, Catholic University of America.

April 18, 1933, 646th regular meeting, *The cultures of Stone Age Man in the Old World,* by L. LORNE WEDLOCK.

October 17, 1933, 647th regular meeting, *Notes on southeastern aboriginal history,* by Dr. JOHN R. SWANTON, ethnologist, Bureau of American Ethnology.

November 21, 1933, 648th regular meeting, *Religion of the eastern Cree,* by Dr. JOHN M. COOPER, Catholic University of America.

The regular December meeting was cancelled by the Board of Managers.

All regular meetings were held in room 43 of the new National Museum.

FRANK H. H. ROBERTS J.R *Secretary.*

GEOLOGICAL SOCIETY

506TH MEETING

The 506th meeting of the Society was held in the Assembly Hall of the Cosmos Club, Oct. 25, 1933, President C. N. FENNER presiding.

Informal communication.—W. H. BRADLEY presented graphs showing the existence of a 10 year cycle in the growth rings of silicified coniferous wood from the upper part of the Green River formation (Eocene) of Wyoming. It seems probable that this cyclic growth is to be correlated with the cycle of sun spot numbers though it may well have been modified by other factors.

Discussed by Mr. F. E. MATTHES.

Program: CHAS. B. HUNT: *Tertiary structural history of parts of northwestern New Mexico.*—The structural deformation of the southern San Juan Basin, New Mexico, is closely related to important nearby uplifts. These uplifts are: The Zuni Mountains, an asymmetric anticline with steep west flank; Mesa Lucero, a broad gentle dome abruptly faulted down on the east side; Sandia Mountain, a block mountain, tilted east and downfaulted on the west; and the Nacimiento Range, an asymmetric anticline with local reverse faulting along the steep west flank.

Several groups of rocks in the region contribute to determining the sequence and age of the deformation. The earliest are Cretaceous sedimentary formations which comprise most of the surface rocks. The porphyritic lavas erupted by the Mount Taylor volcano overlie the northward tilted and folded Cretaceous, and were followed slightly later by sheet basalts erupted on erosion surfaces around Mount Taylor. The fluviatile Santa Fe formation of this region was apparently deposited in the topographic depression that resulted from the down faulting of the graben between Mesa Lucero and Sandia Mountain. The deepest part of the depression was probably near the present Rio Grande, and successively younger beds overlapped the sides of the subsiding trough. Random collections of vertebrate fossils indicate late Miocene and Pliocene age, but the Santa Fe locally overlaps erosion surfaces only 100 feet above arroyo bottoms and only 50 feet above flood plains in which the arroyos are incised. Accordingly, some of the youngest Santa Fe beds may be younger than Pliocene. The sheet basalts around Mount Tay-

lor seem to be about the same age as the lower part of the Santa Fe, and the Mount Taylor eruptions are therefore probably middle or late Miocene.

The deposition of the Santa Fe followed all except the very latest block faulting in the graben. The faulting had therefore mostly taken place before late Miocene but continued into the Pliocene. The northward tilting and associated folding of the southern San Juan Basin involved the early Eocene Wasatch formation but had occurred before the eruptions of Mount Taylor. The deformation was produced by the uplifts of the Zuni and Lucero regions which can, therefore, be limited as post-early Eocene and pre-late Miocene. There is stratigraphic evidence that Sandia Mountain was formed contemporaneously with the graben faulting. The Santa Fe is involved in the latest movements at the north base of the mountain the same as farther east.

The Nacimiento uplift is post-early Eocene for the Wasatch is turned up steeply along the west flank. The presence along the range of undisturbed erosion surfaces at roughly the same elevation above present drainage as the basalt-covered surfaces around Mount Taylor indicates that the Nacimiento Range is pre-basalt in age. Renick has reported that the Santa Fe is involved in the Nacimiento uplift. There is a transition zone a few miles wide at the south tip of the uplift and north edge of the graben, and late movements of block faulting in this transition zone involve the Santa Fe as they do farther south in the graben. But so far as now known the Santa Fe is not involved in the uplifting. The fact that the Santa Fe locally rests on only slightly disturbed erosion surfaces sloping from the Nacimiento is confirmatory evidence that the uplift is pre-Santa Fe. Its date therefore is probably post-early Eocene and pre-late Miocene. (*Author's abstract.*)

Discussed by Messrs. SEARS, G. R. MANSFIELD, TRASK, RUBEY, and C. S. ROSS.

C. P. ROSS and CHARLES MILTON: *Stratigraphic correlation by heavy minerals in Paleozoic beds in Idaho.*—In order to assist in the stratigraphic correlation of the different Paleozoic formations in the Bay Horse region, Idaho, a study was made of the heavy mineral content of 46 specimens from this and neighboring areas. The specimens were not collected with this purpose in mind and a number were unsuited to it. All the rocks studied were thoroughly cemented, largely recrystallized and metamorphosed to a greater or less extent. Some had undergone intense contact metamorphism. Many contained abundant flaky carbonaceous and argillaceous material. In spite of these disadvantages the results are sufficiently distinctive and consistent to have suggestive value in correlation. The principal question was as to the correlation of certain contact metamorphosed beds in the western part of the Bayhorse region. Eliminating from consideration minerals of probable syngenetic origin, the detrital heavy minerals in these beds accord closely with those in beds of known Carboniferous age in the Hailey quadrangle and are quite different from the assemblages of detrital heavy minerals found in any of the older rocks studied. This fact accords with other evidence and the conclusion is regarded with confidence. Other distinctions can be made on the basis of differences in the assemblages obtained from different rocks but these are somewhat less positive.

In general, the results of the study indicate that even in sedimentary rocks poorly adapted to it by reason of induration and metamorphism the investigation of the content of detrital heavy minerals may yield information of value. (*Authors' abstract.*)

Discussed by Messrs. FENNER and FERGUSON.

EUGENE CALLAGHAN: *Some aspects of the geology of the Cascade Range in Oregon.*—The results of field work in the Cascade Range south of Mount Hood during two seasons—one of which was under the direction of Prof. A. F. Buddington—as well as the data published by other workers, permit a few generalizations concerning some of the geological features of this large region of volcanic rocks. In a certain sense the Cascade Range is the dissected western margin of the large plateau-like area of dominantly volcanic rocks in the northwestern part of the United States. This is particularly true of the range in California and in the southernmost part of Oregon, but farther north topographic features, distribution of rock types, and linear elements appear which distinguish the Cascade Range from adjacent physical divisions.

For the geologic description it is convenient to divide the range south of Mount Hood into two parts, to which the terms Western Cascades and High Cascades are applied. This is largely on the basis of a pronounced unconformity in the stratigraphic sequence of lavas and consequent topographic differences. The High Cascades is the easternmost belt and is characterized by rolling upland, partly or wholly preserved volcanic surfaces, and volcanic cones in various states of preservation. The Western Cascades is characterized by deep dissection, lack of preserved uplands, and long ridges sloping toward the major drainage lines.

The rocks of the High Cascades are greatly varied, but the western margin of the area is composed chiefly of olivine basalt which extends in long tongues down valleys in the Western Cascades. The large cones appear to consist chiefly of hypersthene andesite. The lower limit of age of the rocks of the High Cascades is not known, but they are believed to be largely of Pliocene and Pleistocene age. They have not been deformed appreciably.

The older rocks of the Western Cascades are divided into two groups on the basis of dominant rock type and associated structural features. One group is characterized by black glass-bearing lavas which are chiefly andesites but contain some basalt. These occur in two areas along the western margin of the Western Cascades—one in the Rogue River Valley area and the other along the east side of the Willamette Valley. In most places these rocks dip to the east or northeast. Those in the Rogue River area range in age from Eocene to middle Miocene. The second group occupies the remainder of the Western Cascades and is characterized by labradorite andesite, but contains many other varieties. Because these flows are heterogeneous, deformation structures cannot be readily ascertained but both warping and faulting have been noted. These rocks are younger than most of the black lavas but are believed to be largely of Miocene age.

Linear elements of the Cascades include the elongate outline of the range as a whole; a line of quicksilver deposits on the western margin between Black Butte and Rogue River; a line of complex sulphide mineral deposits which coincide for the greater part of its length with a line of stocks, dikes, and plugs of porphyritic diorite and granodiorite extending almost through the center of the Western Cascades; and the belt of volcanic cones in various states of preservation extending throughout the High Cascades.

The ten mineralized areas have a recorded production of approximately $1,000,000, almost entirely in gold from the oxidized portions of sulphide veins. In the unoxidized condition these veins are characterized by sphalerite, galena, chalcopyrite, and pyrite. Tetrahedrite, bournonite, and arsenopyrite occur in some veins. Quartz is the chief gangue mineral, but many

others occur—including johannsenite, a new manganese mineral described by Mr. Schaller. Some evidence of areal zoning of mineralization was found. (*Author's abstract.*)

507TH MEETING

The 507th meeting of the Society was held in the Assembly Hall of the Cosmos Club, Nov. 8, 1933, President C. N. FENNER presiding.

Informal communications.—PARKER TRASK reported on two publications of the results of the German Atlantic Expedition of the Meteor in 1925 to 1927. The expedition studied all features of the Atlantic Ocean between latitudes 20° N. to 60° S. The publications of the Expedition are expected to provide the greatest advance in oceanography since the Challenger Expedition. One of the reports by H. Wattenberg is a comprehensive treatise on the calcium carbonate and carbon dioxide content of the sea water. It contains many tables relating to the factors influencing the solubilities of these substances in the sea water. Maps are presented to show that the saturation of the surface water with calcium carbonate increases from 100 per cent in the southern part of the South Atlantic to 150 per cent at the equator. The water below a depth of 100 fathoms is reported to be between 90 and 100 per cent saturated with calcium carbonate. The influence of boron is ignored in the computation of these figures. If they are corrected for boron, they become about 50 per cent greater for surface water, but not much greater for subsurface water which has a lower pH. The second report by Wüst discusses the circulation of the bottom water. It contains many tables and maps among which is one emphasizing the northward drift of Antarctic water at the bottom of the Atlantic.

Discussed by Mr. BRADLEY.

A. R. BARWICK exhibited a specimen of *Cuculea gigantea* from the lower Eocene Aquia formation collected at Fort Washington which contained a pearl-like growth.

Program: CHARLES B. READ and ROLAND W. BROWN: *Genus* Tempskya *in western North America.*—The fossil ferns called *Tempskya* differ from the common modern ferns in having a trunk known as a "false stem." Externally these fossils have the appearance of petrified palm trunks, but transverse sections of well-preserved specimens reveal their true fern nature. Such sections usually show a number of horseshoe-shaped stems embedded in a mass of roots, the latter being fairly uniform in size, circular in cross-section, and smaller than the stems.

The first American *Tempskya* came from the Patapsco formation of Maryland and was called *Tempskya whitei* by Berry in 1911. In 1924, A. C. Seward described a fine specimen collected from sediments of Colorado age in Montana and called it *Tempskya knowltoni.* During the past few years field work in southeastern Idaho, west-central Wyoming, and eastern Utah has resulted in the collection of much new material which it has been the privilege of the authors to study. Although the authors are not ready to publish the details of this study, enough information has been accumulated to show that these collections contain at least two new species of *Tempskya.* Anatomical details throw new light on the habits and affinities of the genus. It is becoming apparent that these *Tempskyas* may be very helpful in the stratigraphic correlation of the Cretaceous deposits containing them. (*Authors' abstract.*)

Discussed by Messrs. BUTTS, G. R. MANSFIELD, MISER, and GRIGGS.

J. C. REED: *Gravel-filled basins in the Nez Perce National Forest, Idaho.*—The Nez Perce Forest of north central Idaho embraces an area in the Clear-

water Mountains in which are at least half a dozen small basins that contain auriferous gravel. Three of these, those of Elk, Newsome, and Meadow Creeks have been examined in some detail. The basins studied range in length from about 5 to about 10 miles and are about 3 miles wide. Each is surrounded by a bed-rock divide broken only by the narrow, V-shaped canyon of the stream that drains it. Where the basins have not been trenched during the present erosion cycle, the quiet, meandering streams wandering through them are entirely out of harmony with their actively eroding portions farther downstream. The sediments in the basins probably once covered a considerably greater area than at present as is indicated by isolated patches of gravel on certain interstream divides.

The size and shape of the basins, and their location in a region where the bed rocks offer about the same resistance to erosion, appear to rule out the possibility that they were excavated by simple erosion at the heads of certain streams, whereas farther down their courses, the same streams flowing over the same kinds of rocks cut narrow gorges. But, the basins do appear to be at least in part erosional because the floors of the basins extend as benches well up into the basins' tributary valleys except those which enter from the west sides.

The western sides of the basins are straighter and steeper than the others and in one placer pit, along the western edge of Elk Creek basin, Lindgren actually observed a vertical fault separating unconsolidated sediments and gneiss. Large blocks of Columbia lava, more than a square mile in area, have been let down approximately 1000 feet along a fault that still forms a well-defined scarp that bounds Meadow Creek basin on the west. The basins appear to be gravel-covered portions of a pediment-like erosion surface cut off from their normal outlets by structural movements. This pediment-like surface was formed below an older somewhat deformed erosion surface that in this vicinity ranges in altitude between 4500 and 8000 feet above sea level. (*Author's abstract.*)

Discussed by Messrs. ALDEN and BRADLEY.

H. M. EAKIN: *An accidental large scale model of diastrophic action.*—Levee building across old clay-filled basins of cutoff lakes in the Mississippi Valley is frequently complicated by shear failure of the foundation, persistent subsidence of embankment materials, and extensive displacement and deformation of clay formations adjacent to the growing levee. In 1931 one of these failures at Ward Lake, near Sherard, Mississippi, was studied in detail throughout the period of instability.

Immediately following initial failure of the foundation, profiles were run daily over some 25 ranges at right angles with the levee line and corresponding with the standard 100-foot stations of the location survey. After the first few days weekly surveys were substituted and these continued until the levee finally became stable and was topped out.

In addition to recording topographic changes, about 140 borings were made on three selected ranges to determine final underground distribution of fill material. Also, observations were made covering phenomena of expansion and compression; of elevation and subsidence, and horizontal migration of surface areas, of folding, faulting and mass deformation of the surface stratum and of upward migration of clay and local emergence of clays and water at the surface. The old lake bed at this place is about half a mile across. The original clays are 15 to more than 75 feet deep, and overlie gritty sands and gravels. The surface clays are oxidized and somewhat toughened down

to lowest water level, some 10 feet below the surface. Below this the deeper clays are wet, blue, and soft, containing about 45 per cent by weight of water.

The first re-adjustment was a general sinking of the faulted-off portion of the fill from a few inches to about 10 feet on the various ranges, and compensatory uplift along the toe line of the new fill. These movements together comprised a rotation of an elongated body of fill material and underlying clay. At the ends of this prism transverse faults appeared, with opposite differential displacements on the two sides of a relatively undisturbed axis of rotation.

Filling operations from this time onward concentrated on dumping material across the fault line onto the subsiding limb of this rotating prism. The rotation persisted in this zone throughout subsequent operations. Measurement of subsidence was carried on by crow-foot method until it had amounted to 96 feet and was then discontinued. Total subsidence along the fault line must have been several hundred feet.

Along the line of initial uplift at the outer margin of the zone of rotation there appeared, as operations continued, a system of vertical block faults. The blocks tended at first to spread slightly apart, then all tilted their tops back toward the levee so that each rested inclined upon its neighbor. The zone as a whole continued to show tension and spreading. Eventually clays were faulted upward along certain lines among the blocks and both clays and water appeared at the surface along these lines.

The next distinctive zone outward from the levee bordering on the zone of initial uplift and subsequent spread and clay extrusion was that of the outward limb of the initial uplift feature. This limb moved outward and slightly upward without notable deformation. It is apparently a neutral zone of deformative forces, giving a zone of structural integrity. However, this zone represented a maximum of horizontal movement and a minimum ratio of vertical to horizontal displacement. This ratio was about 1 to 10, elevation amounting to 25 feet against horizontal movement of about 250 feet.

Next outside the zone of structural integrity there developed a zone of compression, manifest at first in simple flexures of the crust that gradually became overturned folds and thrust faults. Both overthrusts and underthrusts developed, but overthrusting was predominant. Several grabens developed in which a sinking strip of land was overridden from both sides and finally buried completely. This zone of compression widened by development of new flexures at its outer margin. Each flexure went through about the same history of overturning, faulting, over riding to a position of stability on the succeeding block and then moving outward with the latter in about the same relative position.

Outward beyond the last flexure of the zone of compression was a final zone of disturbance, characterized by simple uplift receding from a maximum of 2 to 4 feet at the toe of the flexure to zero out 150 to 200 feet beyond.

Beneath the tilting blocks and emergent masses of clay in the zone of tension and beneath the deformed surface member in the zone of compression the clays penetrated by borings showed a lack of original structure and cohesion, clearly due to flowage. In the zone of compression this condition was characteristic of the clays from about 10 to 20 feet below the surface. At the margin of the zone of rotation this condition was found under fill at various depths, down to about 55 feet.

It is plain that the general phenomenon is energized by the head of new fill placed in the embankment. This is supportable up to a certain intensity by cohesion and friction in the underlying and adjacent clays, part of the load being transmitted to adjacent lands by the structural strength of the upper member of the clays. Shearing stress is thus at zero under the central part of the fill and at maxima near its margins. The development of actual shear at one or the other of the margins of new fill results in rotational subsidence and displacement of underlying clay. Subsurface currents in the clay are the obvious explanation of the rotation of the fault blocks in the zone of initial uplift and tension; the dragging of strips of land over and under each other in the zone of compression and the elevation of the land surface in the outer zone of simple uplift.

The horizontal extent of subsurface flowage naturally has exceeded surface movements in all situations. Where surface migration has amounted to 250 feet, the increment in cross-section area of lands of the outward zones indicates at least 250 feet additional movement of the underflowing sheet of clay.

The phenomena of the Ward Lake occurrence are generally characteristic of similar occurrences at many other old lake sites in the Valley. This orderliness suggests that the general phenomenon is controlled by definite and perhaps broadly applicable mechanical laws. If these laws are sufficiently general to apply to diastrophic action on a continental scale it would appear that we should be able to identify in the geologic structures of our mountain systems the same general zones of differential forces and movements, namely: 1. A zone of subsidence, perhaps manifest as an off shore deep, or inland graben generally parallel with the shore line or mountain axis. 2. A zone of moderate uplift, expansion, intrusion and extrusion; 3. A zone of moderate deformation and absence of extensive igneous members; 4. A zone of compressional folding and faulting with marked overthrusting, underthrusting and local grabens, diminishing to overturned folds and finally to simple step folds; 5. A plateau region of simple structure, falling off in elevation approximately with the dip of the youngest beds to finally merge with an undisturbed plain. (*Author's abstract.*)

Discussed by Messrs. C. W. Wright, Cooke, G. R. Mansfield, J. C. Reed, Rubey, Alden, Hendricks, Barwick, Butts, Brown, Trask, Bradley, and Hewett.

508th MEETING

The 508th meeting of the Society was held at the Cosmos Club November 22, 1933, President C. N. Fenner presiding.

Program: C. H. Dane and W. G. Pierce: *Fossil sink-holes in Cretaceous beds of Prowers County, Colorado.*—In a small area in sec. 6, T. 22 S., R. 44 W., Prowers County, Colorado, the exposed Upper Cretaceous rocks record the former presence of three sink-holes, between 100 and 200 feet in diameter and from 150 to 250 feet apart. Collapsed and brecciated masses of the Smoky Hill marl member of the Niobrara formation occur in the central parts of two of the subsidence areas and collapsed masses of the Hays limestone member of the Niobrara occur in all three. These collapsed masses are in contact with the upper part of the Carlile shale, which normally underlies the Niobrara formation, and is about 200 feet thick. Some of the collapsed filling has thus dropped 65 feet,—the thickness of the Hays limestone. A normal fault which may have preceded or accompanied the subsidences extends northward between them. It has a downthrow of perhaps 20 feet to the west.

The sink-holes are attributed to removal of soluble material from the Greenhorn limestone, which underlies the Carlile shale, or possibly to removal of soluble salt and gypsum from Permian rocks at greater depths, with subsequent natural stoping upward through the overlying rocks. The solution may have been first localized and aided by downward water circulation along the small fault.

The time of collapse can not be closely dated. It took place before the immediately superjacent topography was developed, for the Smoky Hill marl does not now crop out within two miles of the sink-holes, from which it has evidently been stripped back by erosion. The collapse probably occurred at some time after the irregular folding and faulting that has in places in western Kansas and eastern Colorado deformed the Tertiary sediments which form the surface of most of the High Plains. This deformation should locally, in faulted areas, have allowed downward percolation of ground water to soluble horizons. (*Authors' abstract.*)

Discussed by Messrs. RICE, MISER, THOMPSON, TURNER, MCKNIGHT, JOHNSTON, and MEINZER.

PHILIP B. KING: *The Cretaceous of West Texas.*—Mesozoic deposition began in trans-Pecos Texas in a geosyncline whose trend cut across that of older Paleozoic structural lines. In this area, which lies in the western part of trans-Pecos Texas, a great thickness of sandstone and finer clastic sediments was laid down in late Jurassic and early Cretaceous time. This was followed by the deposition of a great mass of limestone in the geosyncline, but to the northeast the beds of equivalent age are thinner, and change first to a neritic marly facies, and then to a sandy marginal facies that overlapped the Paleozoic rocks. The form and dimensions of the limestone mass are comparable to the early Paleozoic limestones of the southern Applachian geosyncline. The limestones are followed by Upper Cretaceous marine shaly beds which pass upward, east of the Jurassic and Lower Cretaceous geosynclinal area, into continental beds with an increasing amount of volcanic material toward the top. That the volcanic material is indicative of the beginning of a period of diastrophism is suggested by its association with conglomerates which contain fragments of the older rocks. The center of activity must have been to the west, however, for the well rounded pebbles have probably traveled a great distance from their source. Finally, the diastrophic movement culminated at the end of Cretaceous deposition, and the rocks northeast of the geosyncline were broadly folded and deeply eroded. In early Tertiary time, lavas were spread widely over the eroded rocks east of the geosyncline, and in places also overlapped the strongly folded rocks of the geosynclinal area. (*Author's abstract.*)

Discussed by Messrs. SEARS, HESS, and STEPHENSON.

F. E. MATTHES: *Wind-faceted pebbles from the glacial drift of Nantucket.*—A series of pebbles was exhibited showing successive stages in the production of faceted forms by sand blast action—beginning with a pebble having one incipient facet, and leading up to typical "dreikanters" and other multifaceted forms. Criteria were presented for distinguishing wind-cut facets from stream-cut, glacial, and joint facets. The distinctive feature of all wind-cut facets is the sharp, clean cut terminal edge at the leeward border. The windward border is commonly rounded, often grooved. Facets cut on convexly curved pebbles tend to become nearly plane, sometimes slightly concave. On multifaceted pebbles that have had a long and varied eolian history nearly all the facets may be bounded by sharp edges in consequence of the progressive encroachment of new facets on old ones.

Stream-cut and glacial facets seldom have sharp, clean edges, as the fluvial and glacial processes work rudely, each in its own way. Joint facets as a rule have sharp edges, but these are in detail ragged and splintery. Their surfaces, though approximately plane, likewise are in detail rough and broken by minute scarps, scales, and other irregularities.

High polish is not an invariable characteristic of wind-faceted pebbles. Many of the most beautifully faceted pebbles on Nantucket, although well preserved, have a dull, mat finish. This is due, probably, to their having been cut by coarse sand driven by violent gales. A finer abrasive, actuated by moderate winds, would doubtless have given them a more perfect, gleaming polish.

Wind-faceted pebbles have been found in the glacial deposits of Nantucket, Martha's Vineyard, and neighboring portions of the main land by several observers, notably by Shaler, Gulliver, W. M. Davis, Woodworth, and Bryan, yet there is still uncertainty as to the time when the sand blast action prevailed. Wind-cut pebbles abound in the hummocky kame moraine that covers a large part of Nantucket, but that deposit, having been much disturbed by the overriding ice, affords no satisfactory clew to the period of eolian activity. Much clearer is the evidence presented by the Squam Head bluff. It shows the wind-cut pebbles in place, in thin layers of gravel associated with beds of compact sand that are gently flexed and only locally contorted. These beds, 30 feet in aggregate thickness, are believed to form part of an outwash apron that was laid down in front of the continental ice sheet. They rest on the eroded surface of a body of old, blue gray till, and are capped by a thin layer of later, buff colored till, in all probability of Wisconsin age.

Now it is a notable fact that the pebbles in the sandy beds have the same fresh, almost unweathered appearance as those in the overlying till. It seems entirely probable, therefore, that the two deposits are essentially contemporaneous. Indeed, the interpretation that seems best to fit the facts is that the sandy beds were deposited in front of the advancing Wisconsin ice sheet and ultimately were overridden by it.

All the evidence tends to show that the outwash apron was laid down subaerially—the ocean level at that time being lowered presumably by reason of the storage of water in the ice sheets on the continents. It may be concluded, therefore, that the sandblast action which shaped the pebbles took place on the bare surface of the outwash plain that stretched in front of the Wisconsin ice sheet while that ice sheet was approaching its maximum extension. Perhaps it was effected by violent anticyclonal winds that were generated over the expanse of ice. (*Author's abstract.*)

Discussed by Messrs. ALDEN, F. G. WELLS, THOMPSON, STEPHENSON, and FENNER.

509TH MEETING

The 509th meeting of the Society was held at the Cosmos Club December 13, 1933, President C. N. FENNER presiding. Vice-President H. G. FERGUSON took the chair during the presentation of the presidential address: *Some magmatic problems.*

41ST ANNUAL MEETING

The 41st annual meeting was held at the Cosmos Club after the adjournment of the 509th regular meeting, President C. N. FENNER presiding. The annual report of the Secretaries was read. The treasurer presented his annual

report showing an excess of assets over liabilities of $1,336.86 on December 13, 1933. The auditing committee reported that books of the Treasurer were correct.

The results of the balloting for officers for the ensuing year were as follows: *President:* H. G. FERGUSON; *Vice-Presidents:* M. I. GOLDMAN and W. T. SCHALLER; *Treasurer:* C. WYTHE COOKE; *Secretaries:* T. B. NOLAN and W. D. JOHNSTON JR.; *Members-at-large of the Council:* G. A. COOPER, L. W. CURRIER, W. W. RUBEY, T. STADNICHENKO, and G. TUNELL. *Nominee for Vice-President of the Washington Academy of Sciences representing the Geological Society:* C. N. FENNER.

W. H. BRADLEY and T. B. NOLAN, *Secretaries.*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

New deal in forestry.—Privately owned forest lands are to be integrated with the national program for conservation and re-growth of forests, according to the recommendations of a conference held under the chairmanship of Secretary of Agriculture WALLACE. This conference brought together representatives of the U. S. Forest Service and other public agencies charged with the care of forest lands, several groups of professional foresters, the U. S. Chamber of Commerce, and the lumber and timber, pulp and paper, and naval stores industries. Their report may well be looked upon as almost an Emancipation Proclamation for the industries dependent upon forests.

"Sustained yield forest management" sums up in four words the New deal for American forests; the abandonment of forests as mines to be exhausted, the discovery of forests as "farms" to be intelligently cultivated.

The end sought, though stateable in a single simple phrase, "sustained yield," is not so simply attained. Many problems, some inherent in the nature of forests, some economic, some involving the human equation, must be solved and their answers reconciled. The conference undertook to do this, at least in outline, in such a way as to include even the individual farmers' timber lots, as well as the huge holdings of private lumber companies and the great state and National forests.

The recommendations of the conference are contained in no less than 46 sections, beginning with the combating of fire, insects, disease, and other natural forces of destruction, and carrying through to suggested sources of funds for the prosecution of new lines of research in the forests. Outstanding suggestions include; consolidation of administration of publicly owned forests, elimination of unnecessary competition in marketing between public and private forests, vigorous pursuit of the present policy of adding to public forests by purchase of new lands, adjustment of tax burdens on private forest lands to encourage rational rather than forced marketing, federal organization of credits, increased protection against fire, establishment of sound lumber specifications, increased appropriations for administration, education, and research.

C.W.A. dismissals and science.—The gradual closing up of the operation of the Civil Works Administration, which involves the dismissal of 400,000 employees at the rate of ten per cent a week until May 21, immediately

affects the scientific departments of the government as follows: The Department of Agriculture is reduced from 91,147 employees to 48,000; the Fisheries Commission from 2,349 to 650; the Bureau of Mines from 446 to 225. In addition, the Coast and Geodetic Survey must discontinue its supplementary control survey, employing about 15,030 men; the Smithsonian Institution its archaeological excavations, employing 1,104, in Florida, North Carolina and other places the one exception being the undertaking in Shiloh National Park; the Tennessee Valley Authority a large number of the 16,588 men at work on improvement projects; the Interior Department 1,762 men on soil erosion work, and the Public Health Bureau 29,779 men on malaria control work, 32,010 on rural sanitation, and 6,572 sealing mines to stop water acidity in the Ohio Valley. Projects under the Department of Agriculture which must be stopped include cattle tick eradication, involving 6,000 men; typhus-fever control operated cooperatively with the Public Health Service, 17,033 men; citrus canker control in Texas, 88; Dutch elm disease control in several New England states, 1,057; phony peach eradication, 1,112; potato weevil eradication, 211; spotted fever control, 369; mosquito pest control, 25,646, and brown-tail moth control, 5000.

National Park Service.—The name, "National Park Service," was reinstated and applied to the Office of National Parks, Buildings and Reservations, by an Act of Congress signed by President ROOSEVELT on March 2. The National Park Service was originally established in 1916 to correlate federal park administration. Its scope was expanded to include care of national buildings and reservations as well, by the consolidation of June 10, 1933, and its name changed accordingly. But the convenience and familiarity of the older and shorter name, together with a wealth of associations in the minds of many persons familiar with the excellent progress of the national parks and monuments during the administrations of the late STEPHEN T. MATHER and of his successor, HORACE M. ALBRIGHT, prevailed to bring about its restoration.

The National Park Educational Advisory Board met in Washington, D. C., on February 26 and 27. The members of the board in attendance were Dr. H. C. BUMPAS, Chairman; Dr. W. W. ATWOOD, Dr. W. W. CAMPBELL, Dr. WALDO G. LELAND, and Dr. FRANK R. OASTLER.

Many important problems relative to educational policy were passed upon. Of particular importance were reports on historical developments presented by chief historian VERNE E. CHATELAIN of the National Park Service, and a plan outlining museum development in the whole national park system presented by ANSEL F. HALL, chief of the Field Division of Education and Forestry of the National Park Service.

Bureau of Plant Industry.—The Bureau of Plant Industry, United States Department of Agriculture, has issued the first in a series of publications describing types of American varieties of vegetables. This series is intended to remedy the lack of generally accepted, authentic, and adequate descriptions of vegetables varieties, and to remove the confusion as to just what characteristics a given variety should possess. The work is based on cooperative studies by the Bureau and certain state experiment stations and is designed to present the consensus of opinion of the seedsmen, vegetable growers, canners, and horticulturists who are best qualified to judge what type should be established as a standard. The publication recently issued describes the nine principal varieties of tomatoes and contains numerous illus-

trations, some of them in color, showing plants and fruits. Similar works on cabbage and peas are in press, and others are in preparation.

World veterinary congress.—President ROOSEVELT, Secretary of Agriculture WALLACE, and a number of officers of the U. S. Department of Agriculture will cooperate with other American scientists as hosts to the Twelfth International Veterinary Congress, which will meet at the Waldorf-Astoria Hotel in New York, August 13 to 18. This is the first time this body has met in the United States, previous meetings having been held in Europe. The object of the congress is the advancement of the science and practice of veterinary medicine and surgery. Besides the presentation of papers on scientific and practical veterinary questions of world scope, the program provides for an interchange of opinions and experiences among the delegates.

FRANKLIN D. ROOSEVELT, President of the United States, is patron of the congress and HENRY A. WALLACE, Secretary of Agriculture, is vice patron. Prof. Dr. E. LECLAINCHE, director of the Bureau of Epizootics, Paris, France, is president of the permanent committee in charge of arrangements, and Dr. JOHN R. MOHLER, chief of the Bureau of Animal Industry, U. S. Department of Agriculture, is a vice-president and will present one of the principal papers. Other Department officials and scientists on the program are Dr. W. E. COTTON, Dr. A. E. WIGHT, Dr. M. DORSET, Dr. M. C. HALL, Dr. E. C. JOSS, all of the Bureau of Animal Industry.

NEWS BRIEFS

So strong was the Utah earthquake of March 12 that it was registered on instruments at the U. S. Coast and Geodetic Survey observatory at Cheltenham, Md., which are primarily intended for recording of the magnetic field of the earth. For ten minutes at the time of the main shock the magnetic needle wrote a record of the earth tremors and in the afternoon another shock set them in motion for eight minutes.

A new trap developed by W. D. REED of the U. S. Department of Agriculture functions efficiently against the cigarette beetle, one of the most destructive enemies of stored tobacco.

The first joint meeting of the Institute of Radio Engineers and the American Section of the International Scientific Radio Union has been announced, to be held in Washington on April 27.

The Smith-Reed-Russell lecture for March at the School of Medicine, George Washington University, was given by Dr. JOHN WHEELER, professor of ophthalmology in Columbia University and director of the ophthalmological Institute. Dr. WHEELER spoke on *Exophthalmos.*

In a statement issued on February 22, members of President Roosevelt's Science Advisory Board strongly condemned the oft-repeated declaration that "science destroys jobs," asserting that on the contrary research opened the way to more and pleasanter employment opportunities.

A C.W.A. worker in the Smithsonian Institution library discovered in a German book printed within twenty years after Columbus' death a most unconventional description of the great navigator: it characterized him as big, brave, and sharp-eyed, and said he had a "long, red, freckled face." The book is now being translated into English.

The third Arthur lecture was given on the evening of February 26 by Dr. Charles G. Abbot, secretary of the Smithsonian Institution. Dr. Abbot spoke on *How the sun warms the earth.*

The discovery of an important center of Maya civilization, bridging a gap between Old Empire and New Empire cultures, was announced on February 24 by the Carnegie Institution of Washington.

"Heavy water" accumulates in willow shoots, apparently through differential evaporation, researches by the late Dr. Edward W. Washburn and his associate Dr. Edgar B. Smith of the National Bureau of Standards, indicate. Their paper was published in *Science.*

The following radio talks were given under the auspices of Science Service, over the network of the Columbia Broadcasting System: February 28, Dr. Frank Lorimer, *Population trends of American groups;* March 7, Dr. Walter T. Swingle, U. S. Department of Agriculture, *New crops for the American Sahara.*

Personal Items

Jay N. Darling of Des Moines, Iowa, has been appointed chief of the Bureau of Biological Survey, U. S. Department of Agriculture. Although he is known to the public chiefly as one of the outstanding cartoonists of the world, Mr. Darling has also been for many years an enthusiastic and careful student of wild life and a strong conservationist. Paul G. Redington, whom Mr. Darling succeeds in office, was transferred at his own request to the Forest Service on March 1. Previous to his appointment as chief of the Biological Survey seven years ago, Mr. Redington had been for twenty-three years with the Forest Service.

G. H. Barnes of the Canadian Forest Service, on a three-months' detail in Washington, with Francis X. Schumacher of the Branch of Research, U. S. Forest Service, is making a study of methods of predicting growth in the uneven-aged spruce forests after partial cutting.

Dr. John C. Merriam, president of the Carnegie Institution of Washington, read a paper on *Conservation and evolution in a changing social program* before a stated meeting of the American Philosophical Society in Philadelphia on March 2.

Prof. W. H. Twenhofel of the University of Wisconsin, chairman of the division of geology and geography, National Research Council, has been elected chairman of the Tri-State Geological Field Conference of Wisconsin, Iowa, and Illinois.

Dr. Walter C. Lowdermilk of the California Forest Experiment Station, Berkeley, has been appointed vice-director of the Soil Erosion Service of the U. S. Department of the Interior.

Lieut.-Comdr. T. G. W. Settle, U.S.N., spoke on February 8 before the Physics Club of the University of Chicago on *The physics of free ballooning.*

H. H. Nininger, curator of meteorites at the Colorado Museum of Natural History, spoke before the Cosmos Club on the evening of February 19.

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Vol. 24 May 15, 1934 No. 5

MATHEMATICS.—*Flatland: Not a romance but a necessary expedient.*[1] O. S. Adams, Coast and Geodetic Survey.

The Philosophical Society of Washington has been in existence long enough to have certain well-established customs and traditions. One of these is that an expiring president may have the right and in fact has the duty thrust upon him of singing his swan song before passing into the discard. Another tradition is that this president may have the privilege of speaking upon any subject he may choose, and without consulting the all-powerful communications committee. The subject chosen may be one connected with the work of the speaker or it may be merely a hobby in which he is especially interested. Before entering on a discussion of the subject in hand, I shall give a short history of the way in which my interest in it was aroused.

Immediately after we entered the World War, the subject of map projections came into great prominence. It was reported that the maps in the war zone in France were constructed on the Lambert conformal conic projection with two standard parallels. At once the Army and Navy officials were anxious for information about such projections, how they were computed, how constructed, and what were their special properties. At a meeting of such officials Major Bowie, chief of the Division of Geodesy of the Coast and Geodetic Survey, stated that he had men in his division who knew all about such matters. The next day he called me into his office and told me it was up to me to substantiate his statement. As a matter of fact my knowledge of such subjects was very hazy if not altogether non-existent. However I immediately set to work consulting such authorities as I could find who dealt with the subject. I at once found that there was no adequate discussion of either the Lambert projection or of map projections in general in existence in the English language. One had to

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consult works in either French or German to get any real grasp of the subject. I was at once struck with admiration by the skill of Johann Heinrich Lambert in devising the projection and by the elegance and generality of the treatment of Gauss and LaGrange. Ever since that time the general subject of map projections has been one of my hobbies and an avocation in which I always have a lively interest.

After getting a clear grasp of the general theory of the projection, it was difficult to determine from the meager reports that we had just what the French were doing in their practical construction of the maps in France. Mr. Deetz, one of our experienced cartographers, wrote a publication on the subject of this projection in which I gave some account of the general theory. With regard to its specific use in France we had to make some guesses that were later shown to be not exactly in accordance with the usage in France. It was at this time that I gave a paper before this society on the subject of the Lambert projection. Much interest was manifested at that time because it was a subject of much practical import to those who were destined to take part in the war.

This then was the occasion of my introduction to the general field of map projections. From that day to this my interest in this line of work has remained unfailing and I shall now take it upon myself to inflict some of my enthusiasm upon you. I shall not however trouble you with elaborate mathematical formulas, but I shall endeavor to convey some ideas to you on the subject that may be found of some interest and perhaps of some use.

Places on the earth's surface are located by latitude and longitude; that is, they are assigned a definite position in the network of meridians and parallels that are conceived of as covering the surface of the earth. For every point there is a unique latitude and longitude that applies to that point and to no other. A map projection is an orderly arrangement of two sets of lines or curves, one set to represent parallels and the other set to represent the meridians. They must be ordered by some law because they must have a sequence ordered as are the meridians and parallels themselves. This orderly arrangement may come from direct geometric projection or it may be expressed in mathematical terms. Of course all projections can be stated in mathematical terms, but sometimes a projection is more directly in evidence when considered as a true geometric projection. It is rather unfortunate that all possible schemes are called projections for in some cases it is rather difficult to interpret them in the way of geometric projection.

Oscar S. Adams
President, Philosophical Society of Washington
1933

The difficulty that we have to face in any method of projection is due to the fact that the earth's surface is a curved spheroidal surface and consequently no part of it can be flattened out in a plane without distortions. There is no such thing as a perfect map of any part of the earth's surface. In wrestling with problems of this nature we may wish that the earth were flat, as some religious sects contend that it is, or at least that it were a developable surface such as a cone or a cylinder, but if either of these conditions were so I fear we should as a consequence be plagued with greater evils. We might better "bear those ills we have than fly to others that we know not of."

Since the spheroid is not a developable surface and cannot be represented on a plane accurately in all parts, any map must be a compromise between the various desirable properties. There are, in the main, four things to be considered in regard to any map in question. These are:

1. The accuracy with which a projection represents the scale along the meridians and the parallels.
2. The accuracy with which it represents areas.
3. The accuracy with which it represents the shape of the features of the area included.
4. The ease with which the projection can be constructed.

The scale of a map in a given direction at any point is the ratio which a short distance measured on the map bears to the corresponding distance upon the surface of the earth. The definition must be limited to short distances, because the scale of a map will generally vary from point to point; in other words we must limit ourselves to small elements of length in the way that is familiar to every beginner in the calculus.

We must be careful, in comparing distances, to choose directions that really correspond to each other upon the earth and upon the map. The meridians and parallels on the earth intersect everywhere at right angles; but there are many map projections in which the corresponding lines do not intersect at right angles. In such projections, two directions at right angles on the earth would not necessarily correspond to two directions at right angles on the map. We can avoid confusion if we confine ourselves as much as possible to the consideration of the scale along the meridians and parallels of the map, which necessarily correspond to the meridians and parallels on the earth.

We should like to have the scale of the map correct in every direction at every point. If this could be done, the plane map would be a

perfect representation of the spheroidal surface of the earth. Since this is impossible, the scale cannot be correct in all parts of the map. We are, however, able to choose some one direction and hold the scale constant in that direction; as, for instance, along the meridians or along the parallels. When this is done, the scale in other directions will be wrong at nearly all points.

In what is called the zenithal equidistant polar projection, the scale is constant along the meridians. We denote the scale along the meridian by k_m; in this case $k_m = 1$; that is, it is constant. We denote the scale along the parallel by k_p; in this projection then $k_p = z/\sin z$ which is a variable quantity, z being the angular distance from the pole.

An orthogonal polar geometric projection on the plane of the equator holds the scale constant along the parallels. In this case $k_m = \cos z$ and $k_p = 1$. The distortion of scale in this projection is more noticeable than in the case of the equidistant projection, and, in fact, it is greater as well as more self-evident. This is approximately the way a map drawn on a globe would appear when looked at from a great distance. Also, it is about the way that the surface of the moon looks to us. Of course the point from which geometric projection lines would have to be drawn must be an infinite distance away since the projecting lines are all perpendicular to the mapping plane. However for practical purposes the distance of the moon from the earth may be considered as belonging to the junior order of infinities. Considered by and large, the best we can do for our satellite is to represent its surface on such a projection since it persists in turning the same face to us at all times.

In the general theory of projections there are two classes that are much used in the actual construction of maps. These are what are called the conformal projections and the equal area projections. In the conformal projections the scale is constant in all directions for infinitesimal distances at a given point. In consequence of this, the angles formed by curves on the earth are preserved in their projections on the map. Since the meridians and parallels on the earth intersect at right angles, the lines or curves representing them on the map must also intersect at right angles. In all such maps, there must necessarily be points at which this preservation of angles breaks down unless the projection passes off to infinity. Even there, if we choose to consider infinity as a point, the conformality fails. In the well known Mercator projection, if we look upon the meridians as meeting at infinity they will all meet at zero angle since they are represented by parallel straight lines.

An equal area projection is one in which the ratio of area is constant for all parts of the map; that is, a square inch in one part of the map will represent the same area on the earth that a square inch in any other part of the map would represent. Of such a map we could say in general that a square inch of the map represents a certain number of square miles on the earth. The ratio of area is held constant by making the ratio of length vary at a point in different directions. If the scale is too great in one direction there must be other directions in which it is too small if the ratio of area is to be maintained constant. In a great many equal area projections the meridians and parallels of the map do not intersect at right angles. On the other hand, if they do so intersect, the scale ratios along the meridians and along the parallels are reciprocals of each other; that is, $k_p k_m = 1$.

One of the best known conformal maps is the one based upon the Mercator projection. This is frequently spoken of as a projection upon a cylinder tangent at the equator. This has caused many to think of it as a perspective or geometric projection upon the cylinder with all of the projecting lines radiating from the center of the sphere. I am acquainted with a work issued by two university professors in which this statement is made and I have heard the same statement made by others who should know better. In the Mercator projection of the sphere the scale increases as the secant of the latitude; in the cylindrical perspective projection the scale along the meridian increases as the square of the secant of the latitude. The distance from the equator of any point on the map would be given by $s = a \tan \phi$; hence the most elementary knowledge of the calculus would show that

$$\frac{ds}{a d\phi} = \sec^2\phi.$$

Now in the Mercator projection the arcs of all parallels are kept equal to the same arc on the equator; hence the scale in the longitudinal direction is equal to $\sec \phi$ and since the scale is constant at a point, the scale along the meridian at the point is also equal to $\sec \phi$ and not $\sec^2\phi$ as in the perspective projection. It is thus often misleading to speak of the tangent cylinder in connection with the Mercator projection.

The stereographic projection is one of the oldest projections that is still in use. It is said to have been used by Hipparchus for a map of the celestial sphere as early as 130 B.C. This is a true perspective or geometric projection from a point diametrically opposite to the point of tangency of the mapping plane. In the polar stereographic projection when the north pole region is being mapped, the south pole is

the point from which projecting lines are drawn. This projection is a conformal one and hence this class of projections was one of the earliest to be introduced. The point of tangency can be anywhere on the sphere so that the neighborhood of any place can be chosen as the center of the map. When the point of tangency is on the equator, we have what is called the meridian stereographic projection.

The equal area projections are useful when it is desired to preserve the ratio of areas on the map the same as they are on the surface of the earth. They are thus of great importance in showing statistical data in which the relative amounts of area in separate parts enter into the conception.

The Lambert zenithal equal area projection is one in common use in atlases to represent a hemisphere. In the polar projection $k_m = \cos z/2$ and $k_p = \sec z/2$ illustrating the relation $k_m k_p = 1$.

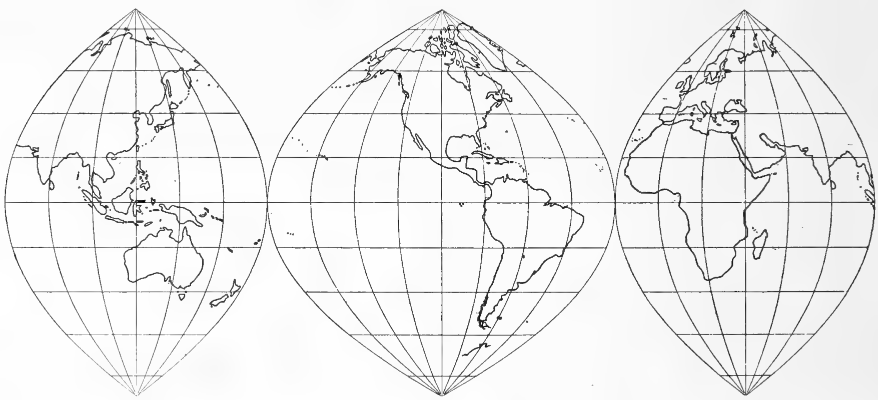

Fig. 1.—Parabolic equal area projections of the world. Compiled and arranged by C. H. Deetz, U. S. Coast and Geodetic Survey.

The Bonne projection is one that is frequently used for maps of Asia. It belongs in the equal area class. Conical equal area projections are very important, especially the Albers projection. The Geological Survey has issued a wall map of the United States with this projection as a basis. Tables for the same were issued by the Coast and Geodetic Survey which were computed under my direction. In late years the sinusoidal projection has been much used for general maps. A somewhat similar and, in some respects, a more pleasing projection is the one called the parabolic equal area projection. This projection is so called because the meridians are arcs of parabolas. It was first suggested by Lieut.-Col. J. E. E. Craster of England and I made some computations from which Mr. Deetz of the Coast and Geodetic Survey constructed an interrupted map of the world. The Carnegie In-

stitution of Washington is using the same projection for a general map of Pan-America for use in studies in genetics.

Many of the equal area maps are much distorted in shape and some of them remind one of images seen in comic mirrors. Werner's heart-shaped map of the world is one such; also Collignon's triangular map of the world and even the cylindrical equal area map.

We should not fail to mention the equal area world maps within an ellipse. We have Mollweide's map with straight line parallels and the Hammer-Aitoff map in the same ellipse but with curved parallels. A rather curious map of this kind is the transverse Mollweide computed by Col. Close of England.

The surface of the earth adopted for mapping purposes is that of an ellipsoid of revolution. This is a more complicated surface than that of a sphere. Latitude upon the ellipsoid is the angle made by a normal to the surface with the plane of the equator. These normals in general do not pass through the center of the ellipsoid. If one wants to compute projections by taking into account the ellipticity of the earth the formulas become quite complicated. In the discussions of the Lambert conformal conic projection, it is usually stated that the geocentric latitude can be used since it differs but slightly from what may be called the conformal or isometric latitude. In the early computations that I directed and made, this latitude was used. My attention was drawn to the question of the magnitude of this difference by an inquiry to the Office of the Survey from the venerable James Pierpont of Yale University. He inquired at what latitude this difference was a maximum and what was the approximate size of the difference. I was called upon to answer the query and my interest was thus aroused. All authorities stated that if this isometric latitude were known then all conformal projections could be computed directly from this conformal or isometric sphere. I conceived the idea of taking all different kinds of latitude for which there was any use and developing the differences between them and the geodetic latitude in terms of the sines of the multiple arcs. In all, five kinds of latitudes were thus treated. Tables were then computed that can be used for any future computations.

The isometric latitude is then a conformal projection of the spheroid on the sphere. A conformal projection of this isometric sphere on the plane therefore gives a conformal representation of the spheroid on the plane.

In analogy to this, I had the happy inspiration to project the spheroid on a sphere of equal surface so that the projection was

characterized by equal areas in all of its parts. I had never seen this referred to by any authority; so I gave the name of *authalic* latitude to this conception after Tissot who employed the term *authalique* for all equal area projections. The equivalent sphere is also called the *authalic* sphere.

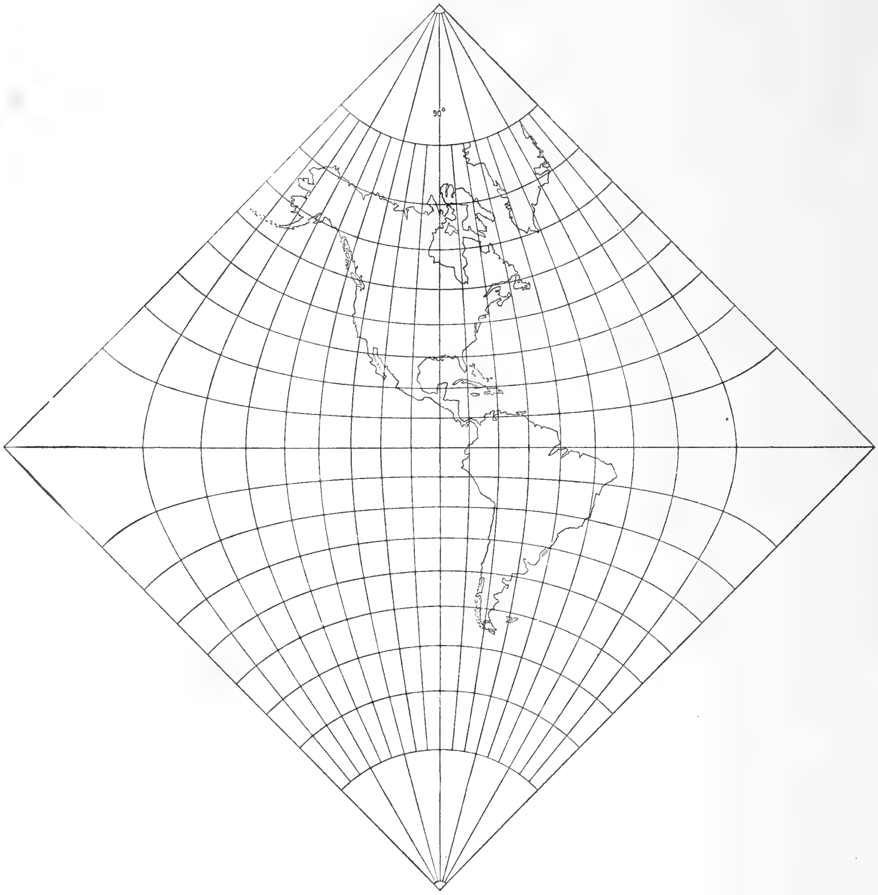

Fig. 2.—Conformal map of the Western Hemisphere in a square.

Another important latitude is the one called the rectifying latitude. A sphere is chosen such that the length of a meridian on it is exactly equal to the length of a meridian on the spheroid. Then corrections to the geodetic latitudes are computed so that each parallel on the sphere is the correct distance from the equator. With these latitudes any arc of the meridian can be computed readily and accurately.

I shall now give some account of a series of projections with which

my name is more directly connected since they are the result of my own investigations. In 1864 H. A. Schwarz proved that a circle could be mapped conformally upon a regular polygon of n sides by means of the integral

$$w = \int_0^x \frac{dx}{(1-x^n)^{2/n}}.$$

This was proved by the theory of functions of a complex variable, and its validity is readily seen to follow from consideration of integrals in that branch of mathematical analysis. Two examples of the results of this theorem had been made, one by C. S. Peirce in 1877

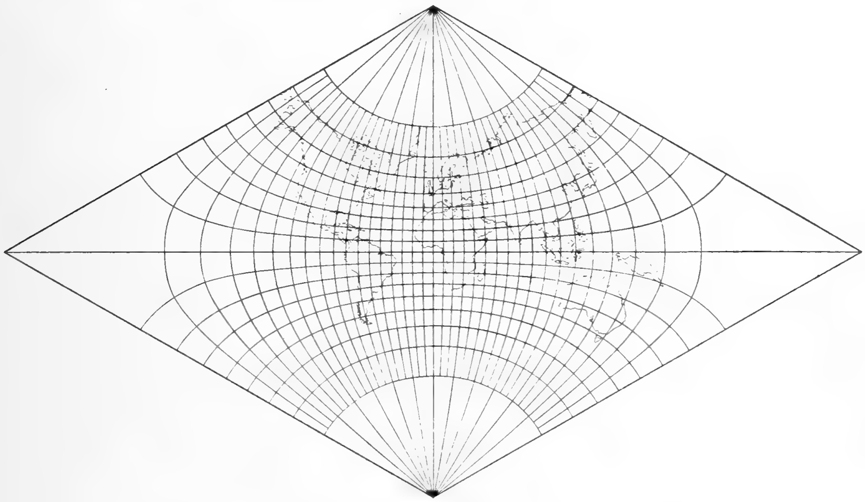

Fig. 3.—Conformal map of the world in a rhombus.

at that time a member of the Coast and Geodetic Survey and one by Lieut. Guyou of France. Both of these depended upon the integral when $n=4$, and hence the maps were enclosed in a square.

Now Gauss and LaGrange had proven that any projection derived by any function of the complex variable for any conformal projection would of necessity give a new conformal projection. Moreover since Gauss established the theorem in all generality, when such projections are formed, we do not need to investigate whether they are conformal. Their conformality follows from the general theorem.

I saw at once that if we could form an algorithm for the computation of the integral

$$w = \int_0^z \frac{dz}{(1-z^3)^{2/3}}$$

we should have a circle mapped within a triangle, and by further manipulation we could map the circle or a hemisphere within a rhombus with one pair of angles 120° and the other pair 60°. One could, of course, develop the integral in a series and use for z the complex variable of the stereographic projection, but this is a laborious process since the series does not converge very rapidly.

As an aid in the formation of computation methods, I decided to invert the integral and to develop the properties of z as a function of w. In 1890 Prof. A. C. Dixon of Trinity College, Cambridge, published a paper *On the doubly periodic functions arising out of the curve* $x^3+y^3-3\alpha xy=1$. On consulting this article, I saw at once that the function that I wished to treat was a special case of the functions that he had developed. If α became zero, then the functions that he had devised became the same as those that I wished to treat. These functions are single valued elliptic functions with many interesting properties. In Special Publication No. 112 of the Coast and Geodetic Survey there is a rather comprehensive account of the function which I denoted, after Dixon, by the symbol *sm w*. By means of the properties of this function, I was able to devise formulas for the computation of the projections.

In all, five different projections were computed with these functions and published in the above-mentioned publication:

1. Northern hemisphere in an equilateral triangle and the whole sphere in a regular hexagon.
2. Western hemisphere in the rhombus, poles in the 120° angles.
3. The same with the poles in the 60° angles.
4. Northern hemisphere in the rhombus, pole at the center of the rhombus.
5. Rhombic projection of the world, poles in the 120° angles.

A projection of the western hemisphere within the Peirce and Guyou square and with the poles in a pair of the angles was also included in the same publication.

A further illustration of the Schwarz integral was computed, based upon 6 as the value of n. This gives the northern hemisphere in a regular hexagon, and the rest of the world mapped on the points of a six rayed star.

As a final example of the use of elliptic functions, for maps, the world was conformally mapped in an ellipse similar to the Mollweide ellipse. This was done in two steps; first a computation was made for a projection within an elongated rectangle. A map was constructed on this grid to show what it was like. By use of a function of the complex

variable of this projection, the final map was made. This map has been reproduced in the recent important French work on projections by Driencourt and Laborde as an example of a planisphere in this ellipse that does not have such violent distortions of shape as have the others mapped in the same ellipse.

Before leaving this subject I wish to call attention to a conformal projection that was computed for Mr. B. J. S. Cahill, an architect of Oakland, Calif. Mr. Cahill calls this projection a butterfly map of the world. It is easy to see that the projection depends on the same elliptic function that I have used for the various other maps within a rhombus. The map is strictly conformal and is computed on the most rigid mathematical basis.

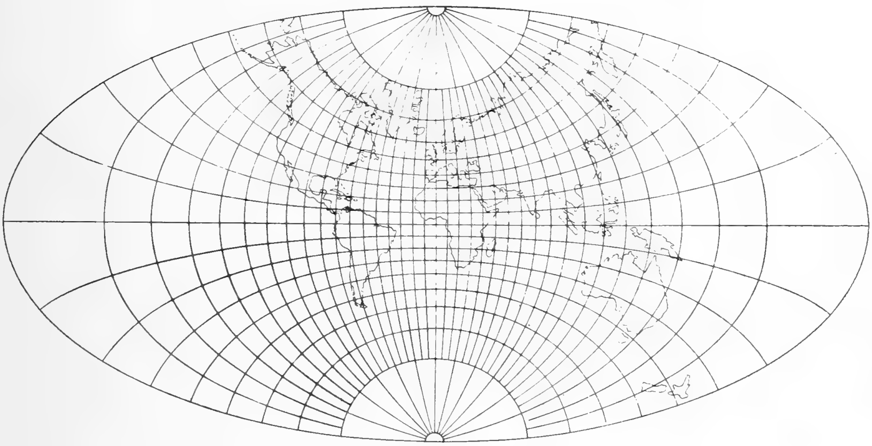

Fig. 4.—Conformal map of the world in an ellipse.

Besides this map, I have computed for Mr. Cahill what he calls his gnomonic variant of the butterfly map. This is in fact a gnomonic projection or a geometric projection from the center of the sphere upon a circumscribed regular octahedron; then this octahedron is split along the edges and spread out into the plane in the butterfly style. In this projection a great circle on the sphere becomes a straight line on the map. Unfortunately we can only consider the earth as a sphere in making such a map. It might be thought that we could first project the ellipsoid on the sphere in such a way that the geodetic lines on the spheroid would become great circles on the sphere. It is to be regretted that this cannot be done. It has been proved that geodetic lines on an ellipsoid cannot in general be projected into straight lines in the plane. Now if such a projection could be made on the sphere the geodetic lines would become straight lines in the plane,

but this is contrary to what has been proved. However for the usual mapping purposes it is sufficiently accurate to consider the earth as a sphere.

I wish here to call attention to an interesting feature in making certain types of maps. I have spoken of the conformal projection of the spheroid upon the sphere as forming a cartographic expedient that is very useful in practice. In addition to this we can map the whole sphere conformally on the half sphere and then project this hemisphere upon the plane within a circle. This is done in the case of Lagrange's projection in which case we can imagine a cut made along a

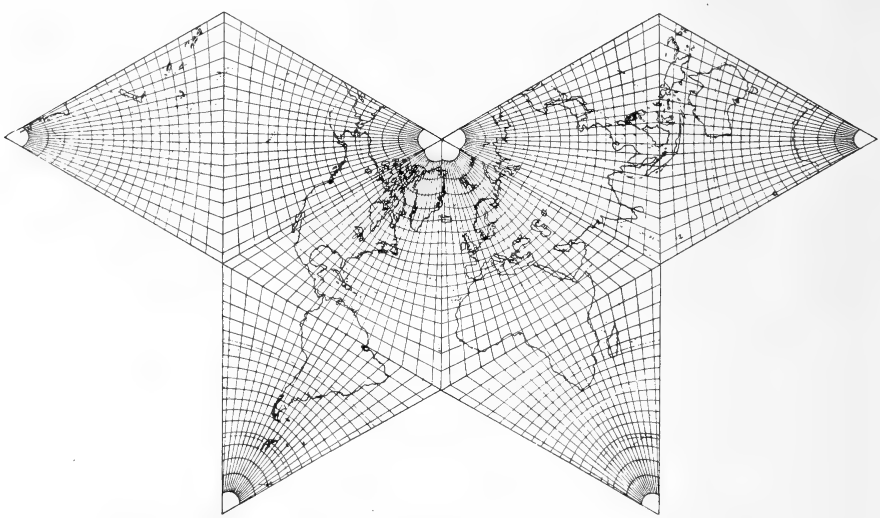

Fig. 5.—Gnomonic map of the world on a circumscribed octahedron.

meridian from pole to pole and then the surface shrinking conformally until the whole surface covers only a half of the sphere. This hemisphere projected conformally on the plane as a meridian projection gives Lagrange's projection of the world within a circle.

As an interesting experiment, I tried cutting along the equator half way around and then causing the surface to shrink conformally until only the half sphere was covered. This hemisphere could then be projected into the plane in a circle as was done in Lagrange's projection. However I computed the same in a square with the poles situated on a diagonal symmetrical with respect to the center. Other arrangements either in a square or in the rhombus that I have already used extensively could be made. It would be interesting to map it in the ellipse that I have already used, placing the poles on the major axis symmetrical with respect to the center. Sometime,

possibly when I have too much leisure on my hands, I may try such experiments.

After the publication of the work on *Elliptic functions applied to world maps,* I sent a copy to Professor Dixon explaining that his article in the *Quarterly Journal of Mathematics* was the source of my inspiration in the subject. I received a very pleasing letter in reply in which he said that as far as he could check up he thought that I was the only one who had ever looked into his article farther than reading the title. He congratulated me very heartily on finding some use for his work.

Using Lagrange's projection of the world within a circle as a basis, we can compute a conformal map of the world within a two cusped epicycloid. This has been done by Prof. August and I have computed a table of coordinates for the same. It could be constructed graphically after the Lagrange projection has been made to serve as a basis, but better construction work can be done by the use of x and y coordinates.

Just recently a new use for some of the more important projections has come to the fore. In this country the Coast and Geodetic Survey has some 40,000 miles of arcs of triangulation. Since these cover great stretches of territory all of the work has to be computed by means of latitude and longitude. The actual surface of the earth is, of course, very irregular but the ideal sea-level surface approximates very closely to the surface of an ellipsoid of revolution. Such a surface has been adopted as the basis of geodetic operations and all of our triangulation is computed on this ideal surface in terms of latitude and longitude and azimuths and lengths.

Now local surveyors in cadastral surveys and surveys for public works are interested in general in much more limited areas. A demand arose from engineers throughout the country for the establishment of plane coordinate systems for regions in which such work was to be done. It has been the custom of most such engineers to establish local systems for their various projects. This led to much confusion when it was desired to extend the work so that various projects overlapped. It was found very troublesome to coordinate the work with what had already been done. Also these local systems are quite limited as to the distance that they can be carried without troublesome discrepancies entering into the work.

It might be said that such engineers should resort to geodetic computations. This is easy to say and we of the Coast and Geodetic Survey have been saying it for many years. However, the trouble is

that "you can lead a horse to water but you can't make him drink." Geodetic computations are rather complicated and, though they are easy enough when one is used to them, it is nevertheless difficult to get the general public to use them. So, "if the mountain will not come to Mahomet, then Mahomet will go to the mountain" and that is exactly what we have done.

In response to this demand for coordinate systems that could be applied to more extensive areas and would still give exactness in computation, I was requested by Major Bowie to look into the matter to see what could be done. The first request came from the engineers of the Public Works Administration of North Carolina. The Coast and Geodetic Survey in cooperation with this state was just completing a network of triangulation over the state that gave excellent control for any engineering work within the region. The state officials were making extensive surveys for roads and other public works and they wanted this control data put on a more practical basis for use by their engineers and the request was a very logical one. All Federal control data should be put in such form as to be most readily available for the engineers who wish to use such control.

After a careful study of the situation we recommended a statewide system of plane coordinates based upon the Lambert conformal conic projection with two standard parallels. Since this gives one system for the entire state, any work done in any part of the state that is based on the general control system is at once coordinated with the work in any other region of the state. Scale discrepancies are found in such an extensive system, but they are definite variations that can be taken into account and computations can be made upon the grid with an accuracy far within the accuracy of ordinary engineering work.

With careful use of the scale factors geodetic accuracy can be obtained. This system has been in use in North Carolina for some time and all the surveys that are being made at the present time are computed directly on this grid making use of the scale factors in all cases. Work of this kind is very active in that state under the state relief appropriations.

After completing the computation for North Carolina a similar computation was made for Long Island. In this system owing to the limited extent in latitude the scale variations could be kept below one part in 100,000 for the island proper with most of it as good as one part in 200,000. This is within the accuracy of even geodetic control,

so it will not be necessary to trouble about the scale factors except for the most exact computations.

As a next experiment, a system for New Jersey was devised, based upon the transverse Mercator projection. This is the well known Mercator projection with its axis turned to an east and west direction in which the coordinates are related to a central meridian in the same way that the ordinary Mercator projection is related to the equator. To give a balance of scale in the system, the scale was reduced one part in 40,000 along the central meridian. This makes the scale exact along two small circles parallel to the central meridian at a distance from it of approximately 28 miles. We might think of this as an intersecting cylinder instead of a tangent cylinder but we have advised against this cylindrical conception of the projection. It is similar to what we should have in the ordinary Mercator projection if the scale were held exact along parallels approximately 28 miles north and south of the equator.

Formulas for the direct computation of coordinates from geodetic positions have been devised for both systems of coordinates. These are comparatively simple and the computations can be made by anyone familiar with the use of logarithms and trigonometric tables. The state tables are made to include all of the data necessary for such computations. After all geodetic stations have been computed in terms of x and y coordinates on the grid, all further computations can be made directly in terms of plane coordinates.

Single systems have also been computed for Maryland, Tennessee and Massachusetts on the Lambert projection and for Delaware on the transverse Mercator. For Iowa, Ohio and South Carolina two systems on the Lambert have been used with the division between them determined by county lines. This will keep each county on a single system. In Florida it was found desirable to employ three systems; two transverse Mercators for the north and south section and a Lambert for the western portion at the north. Georgia, Alabama and Mississippi have been divided into two systems, each on the transverse Mercator, and further systems will be computed just as rapidly as possible until practically all of the states are provided with such aids to accurate computation on the plane.

In our rapid survey of the various and sundry possibilities for flatland construction, we have seen that the ideal map has proved as elusive as Sarah Gamp's Mrs. Harris. The best we can do is to choose the form of projection that is most suitable for the particular purpose that the map is to serve. We should be careful in any case not to draw

conclusions from a map that are not justified by the facts. Even a man in the Coast and Geodetic Survey inquired why ships and aeroplanes go north by way of Newfoundland in going from New York City to England. He said "Why not go straight across and save a lot of distance?" He was thinking in terms of a Mercator projection and not in terms of a gnomonic as should be done in all such cases. A gnomonic map will show that the great circle from New York City to Liverpool passes through Massachusetts west of Boston and over Newfoundland well towards the northern portion. Any route south of this line is necessarily a longer one. The shortest distance from Seattle to Yokohama passes through the Aleutian Islands. That from Panama to Yokohama passes far inland through the states, entering the Pacific near the mouth of the Columbia River.

Even a President of the United States, in his letter of congratulation to an explorer of arctic regions, felicitated him for the discovery of an island westward of the pole. I fear it would tax the ingenuity even of a president to explain in what way any point on the earth *could* be *westward* of the pole. We should attempt to judge things not as they seem but as they are.

I am glad to note that a number of moderate priced globes have appeared on the market in the last few years. This is a matter that I advocated in Special Publication No. 68 which appeared some years ago. Whether my advice has been a factor in causing this new movement I am not able to say, but I do know it is an important move. Even a small globe, though badly fitted together, will give a truer picture of the relative arrangements of the features of the earth than can be secured from the best of maps.

We may not be intentionally misleading as is described by Dean Swift:

> "So geographers, in Afric maps,
> With savage pictures fill their gaps,
> And o'er uninhabitable downs
> Place elephants for want of towns."

Nevertheless, our best efforts are often misinterpreted through lack of insight on the part of the user. Let us all try

> "To know what's what, and that's as high
> As metaphysic wit can fly."

GEOLOGY.—*Supplementary notes on Pleistocene glaciation in the Great Basin.*[1] ELIOT BLACKWELDER, Stanford University.

Since the publication of my paper on the glaciation of the Sierra Nevada and Basin Ranges,[2] I have extended my studies among the ranges of Utah, Nevada, and eastern California. The results, so far as they concern glaciation, are here presented.

Stansbury Range, Utah.—A view from Grantsville affords clear evidence of glaciation near Mt. Deseret (10,250 feet). The topographic forms show that several glaciers occupied canyons in the eastern slope, probably during the Tahoe glacial stage, and descended about half way to the base of the range, leaving moraines of considerable size in the bottoms of the valleys. It seems probable also that the cirques made at that time were refreshed by glacierets during the later Tioga stage. Marsell,[3] who has climbed Mt. Deseret, confirms this opinion and adds the information that several tarns were found in the cirques.

Oquirrh Range, Utah.—According to Marsell, Mt. Lowe (10,200 feet) formerly had glaciers on its eastern slope. The freshness of the cirques indicates the Tioga as well as the Tahoe stage.

Deep Creek Mountains, Utah.—This short range on the western edge of Utah reaches an altitude of 12,100 feet. My only information regarding its glacial history is from Marsell who states that deep cirques and glacial canyons, which he saw from the adjacent plain, indicate vigorous glaciation in both Tioga and Tahoe stages. This range is probably very similar to the Snake Range, farther south, in both form and glacial history.

Pilot Range, Nevada.—A valley head on the northeast side of Pilot Peak suggests by its form and rugged surface a cirque of Tahoe age, but the locality has not been examined closely.

Independence Range, Nevada.—About fifty miles north of Elko, a small group of glaciers once clustered around Jack's Peak (altitude about 11,000 feet). In the Tahoe stage a glacier descended McAfee canyon, on the eastern slope, about 4½ miles and built a moraine on the edge of the plain. The terminal portion has since been eroded away and replaced by a wedge shaped alluvial fan, but the old lateral moraines extending down to the base of the range are still conspicu-

[1] Received Jan. 22, 1933.

[2] BLACKWELDER, ELIOT. *Pleistocene glaciation in the Sierra Nevada and Basin Ranges.* Geol. Soc. Amer. Bull. **42**: 865–922. 1931. In this paper four glacial stages are recognized as follows, beginning with the oldest: 1, McGee; 2, Sherwin; 3, Tahoe; and 4, Tioga. The last of these is believed to be equivalent to the latest Wisconsin moraines of northern United States.

[3] MARSELL, R. E. University of Utah. Oral Communication.

ous. Two smaller glaciers occupied unnamed canyons immediately to the north and another across the ridge to the south. In the Tioga stage there were apparently only three glaciers in this group and the largest was not much more than a mile long. Their existence is indicated by the presence of tarns and by the freshness of the cirques and moraines. Farther south there is similar evidence of two stages of glaciation at the heads of Pratt and Foreman Creeks. No doubt when the western slope of the same mountains is examined evidence of similar glaciation will be found there also.

Along Foreman Creek at least there are two well defined sets of gravel terraces—one 10 feet above the modern flood plain and the other 36 feet. Reasoning from better known terraces elsewhere in the West, I infer that the lower terrace was formed as a valley train at the time of the Tioga glacial advance and the upper terrace during the Tahoe stage.

When these mountains are more carefully examined it is probable that evidence of still older glacial stages will be found.

Jarbidge Mountains and Copper Mountain.—As the highest peaks of this group are, if anything, somewhat higher than Jack's Peak, it is almost certain that they were glaciated likewise. Distant views through a hazy atmosphere were not sufficient to permit me to draw satisfactory inferences.

Ruby Mountains.—The northern part of this range lying between Wells and Secret Pass was formerly known as the East Humboldt Range. Its summits rise to elevations of 10,500 to 11,300 feet but its relief is greater and its slopes steeper than those of the Independence Range. Many of the larger canyons on both flanks were glaciated in both Tahoe and Tioga stages. Those on the west side were apparently the largest—5 to 7 miles long in the Tahoe stage—but did not reach the plain. On the east side those of the same age extended down to the base of the range. The glaciers in Leach and Steel canyons appear to have been the longest—about 3 miles. As usual, the older (Tahoe) terminal moraines have been eroded away, leaving only the lateral ridges. Excellent cirques, still ragged and bare, and small fresh moraines clearly indicate glaciers of the Tioga stage, but none of them came far down the mountain sides South of Johnson Creek, on the eastern slope and Boulder Creek on the west side, no definite evidence of glaciation was observed.

From Secret Pass the main body of the Ruby Range extends southward about 60 miles. Its crest is above 10,000 feet through perhaps half of its length and culminates in Lamoille Peak (altitude

11,128 feet). The eastern slope of the range, being steep and short, afforded less catchment area for snow. Perhaps for this reason none of the glaciers reached the base of the range even in the Tahoe stage, although the Dawley Creek glacier came within about half a mile of the plain. Most of the larger canyons between Lutts Creek and Dawley Creek display the usual moraines and cirques, indicating glaciation in both the last two stages.

On the western slope large glaciers descended Lamoille (13 miles long) and Rattlesnake canyons during the Tahoe stage and extended out upon the adjacent plain. Several intermediate glaciers reached the base of the range. Even in the Tioga stage glaciers several miles long occupied the heads of these canyons.

No clear evidence of glaciation has been observed south of Harrison Pass and nowhere in the range has clear evidence of pre-Tahoe glaciation been found.[4]

During a moister epoch, which probably coincided with the last glaciation in the mountains, an extensive lake occupied the basin east of the Ruby Range. Conspicuous gravel embankments around the northern and eastern sides of the lake and occasional wave-eroded cliffs indicate a lake which was at one time at least 120 feet deep. It has now dwindled to two shallow lakes, of which the northern one is little more than a marsh.

Toyabe Range, Nevada.—The Toyabe Range, culminating in Arc Dome, at an elevation of 11,775 feet, is somewhat higher than the Ruby Range and yet reveals to cursory examination surprisingly little evidence of glaciation. At the head of a canyon on the east slope about 12 miles south of the Lincoln Highway, obscure cirques now much clogged with talus, suggest glaciation in the Tahoe stage only. The canyons around Arc Dome, west of Round Mountain, seem to have harbored glaciers several miles long during the Tahoe epoch, but the cirques are now so subdued that I am disposed to doubt that there were any glaciers there in the Tioga stage. Apparently the most favorable place for glaciers in this range is in the deep canyon south of Arc Dome, a locality not yet examined.

Shoshone Range, Nevada.—These mountains are a northward continuation of the Toyabe Range but are generally somewhat lower in altitude. As seen from the railroad near Beowawe, the highest mountain in this group has a cirque-like hollow on its northeast side that strongly suggests glacial action of Tahoe age.

[4] As mentioned in my earlier paper (Op. cit., p. 911), some indications of till of the Sherwin stage were found west of the mouth of Lamoille canyon, at the western base of the range.

Wassuck Range, Nevada.—This range was evidently too low to induce vigorous glaciation. The only evidence I have observed is a cirque-like excavation on the east side of the highest peak, Mt. Grant (elevation 11,303 feet) which suggests a small glacier of the Tahoe stage.

Sweetwater Range, California.—Being higher (11,646 feet) than the Wassuck Range, the Sweetwater Mountains were fairly well glaciated at least during the Sherwin and Tahoe stages. Subdued cirques and small moraines suggesting glacierets of Tahoe age have been found at the heads of Desert and Deep Creeks on the western slope. On the east flank ice tongues of the same age were somewhat longer and more numerous. Although the canyons there have not been closely examined, the glacier in Sweetwater canyon appears to have been about 3 miles long and extended more than half way down to the base of the range. The cirques are not ragged and clean enough to suggest vigorous ice action in the Tioga Stage.

Near the head of Deep Creek on the western slope a body of much weathered and eroded old till indicates that a glacier of the Sherwin stage about 3 miles long descended below the 9300 foot contour.

White Mountain Range in California.—Although by far the highest mountain range in the Great Basin (summit 14,242 feet) this range was less severely glaciated than the much lower Ruby Range. Only the northern part of the range, about 22 miles in all, gives evidence of strong glaciation. Small glaciers of the Tioga stage are indicated by fairly clean cirques and suggestions of very bouldery moraines at high elevations. In the Tahoe stage much longer glaciers descended the canyons but none of them approached the base of the range closely. On Perry Aiken Creek, on the east side of the range, a remnant of what is probably the Tahoe stage moraine stands at an altitude of about 6,500 feet, 2 miles back from the margin of the range. No evidence of glaciation has been observed south of Milner Creek on the west slope, or on Iron Creek on the east side.

On both sides of Perry Aiken canyon and near the front of the range, bodies of ancient till, now greatly eroded and weathered, probably represent the Sherwin stage. The distribution of these remnants suggests that the glacier of that age extended out to the adjacent plain. The patches of old till lie upon the tops of ridges which themselves have been carved out of granitic rock. In this locality faulting along the base of the range has introduced complications not usually present. From a brief study of the valley I infer that a thick valley train was aggraded below the terminal moraine of the Tahoe stage. A displace-

ment of nearly 300 feet on a fault along the base of the range then caused this deposit to be deeply trenched, leaving gravel terraces of corresponding height along the sides of the canyon. The large fan at the mouth of the present canyon is therefore probably of late Pleistocene and Recent age. It is still growing by the addition of bouldery mudflows at frequent intervals.

Spring Mountain Range, Nevada.—This southernmost range of high mountains in Nevada attains an altitude of 11,910 feet, but apparently it was too far south to receive snow enough for glaciers during the Tioga epoch. The somewhat excavated heads of the canyons surrounding the highest peak afford a suggestion of glaciation during the Tahoe stage. It is still more probable that glaciers were present in the Sherwin stage, but observational evidence is not yet available.

Panamint Range, California.—Although Telescope Peak reaches an elevation of 11,045 feet no good evidence of glaciation has been afforded by views from the base of the range on either side. However, because of its altitude and geographic position, it seems possible that glaciers were present in the Sherwin stage, but scarcely probable that even small glaciers occupied any of the valley heads during Tahoe time.

Other Great Basin ranges of which the highest peaks reached elevations between 10,000 and 11,000 feet may well have possessed small glaciers during the Sherwin and even the Tahoe glacial stage. Most of these mountains have not been examined for evidence of glaciation. In some, the record will doubtless be obscure, and in others, quite lacking.

SUMMARY

The facts which have been derived from this reconnaissance indicate rather clearly that the distribution and intensity of mountain glaciation are influenced by three factors—latitude, humidity, and altitude. In the mountains of Nevada which attain elevations of 11,000 to 12,000 feet the severity of glaciation decreases steadily from north to south, as would be expected. In northernmost Nevada mountains scarcely 11,000 feet high were inhabited by small but vigorous glaciers of Tioga stage, whereas near the southern end of the state, mountains nearly 12,000 feet high had no glaciers at that time.

The influence of humidity is conspicuously shown by the extensive glaciation of the Sierra Nevada, whereas the equally high White Mountain Range, which lies directly east and therefore in the rain-shadow of the Sierra, had only a few relatively small glaciers.

The Ruby Range illustrates the importance of altitude as a factor. In the section where the peaks range in elevation from 10,500 to more than 11,000 feet every canyon held a vigorous glacier. Farther north along the same ridge, where the highest summits rise to only 9,500 to 10,000 feet, there is little evidence of glaciation.

In keeping with the well known fact that the last three glacial episodes in western United States form a declining series, it is clear that in the Great Basin each successive member of that series could form glaciers only at a higher altitude than the one preceding. In central Nevada the mountains below 11,500 feet developed no glaciers during the Tioga ice stage and those below 10,700 feet none in the Tahoe stage. Much less is known about the Sherwin glacial stage but from the greater extent of the ice lobes of that time it seems probable that an altitude of about 9,500 to 10,000 feet may have been sufficient then to induce glaciation. It seems very improbable that any mountains whose summits are less than 9,000 feet in altitude in northern Nevada or 10,500 feet in extreme southern Nevada will be found to show any evidence of Pleistocene glaciation. It is not to be forgotten that some vertical diastrophic movements have occurred in the region since the Sherwin stage, but available evidence indicates that in most places the increase of relief from that cause has been negligible.

BOTANY.—*Microsporum of cats causing ringworm in man.*[1]

VERA K. CHARLES and ALINE FENNER KEMPTON, Bureau of Plant Industry.[2]

It has been recognized for some time that domestic animals and pets may be a source of danger to man as carriers of disease. A case of ringworm infection transmitted by a cat, which came to our attention in 1933 not only demonstrated this fact but enabled us to work out very definitely the exact stages in the transmission of the ringworm fungus from cat to man. The following is a brief outline of the history of the case.

The first victim we will designate as Case I. In this instance a three-months-old Persian kitten had been acquired, and after having it about 3 weeks the new owner developed a few suspicious spots on the throat. The original owner of the kitten had observed a few dandruff-

[1] Received January 29, 1934.

[2] Acknowledgment is made of the assistance of Dr. L. T. Giltner, of the Bureau of Animal Industry.

like particles on the neck especially on the throat of the kitten, but had attributed their appearance to a slight stomach disorder, which seemed to have been controlled before the kitten was acquired by the new owner, or Case I. The later history of the case proved that a cure had not been effected, but the kitten had been combed and cared for so carefully that no evidence of scurf remained. It is important to note that the kitten's home in both instances was an apartment. As previously mentioned, about 3 weeks after the kitten had been acquired several red, oval to round spots appeared almost simultaneously on the throat, chest, and face, especially around the eyes and shoulders of the new owner. Later the affection spread to all parts of the body. These spots were accompanied by intense itching and the infected area became inflamed and feverish. A microscopic examination of particles of skin from the diseased area revealed the presence of mycelium but no fruiting fungus. Cultures made from dandrufflike particles in the hair produced spores, but no typical lesions developed on the scalp.

Cultures were made on Sabouraud medium from scrapings from the affected parts, and in three days the fungus was fruiting abundantly. As soon as the mycelium was found suspicion was directed to the kitten. The animal was immediately brought to the laboratory and on careful examination showed a few dandrufflike particles. A microscopic examination of this material also disclosed mycelium. Cultures were made on Sabouraud with the result that in three days the fungus was fruiting abundantly. The two cultures, one from the human skin and the other from the cat, proved to be identical.

When the cultures were about ten days old, two healthy short-haired cats were inoculated, one from the human inoculum and one from the strain from the cat. With the latter strain two methods of inoculation were used: (1) hairs from the diseased kitten were placed on a scraped spot of the skin of the cat to be inoculated; (2) a bit of the fruiting fungus was placed on a scraped spot of the skin of the other healthy cat. All inoculations were positive and no difference could be observed in the virility of the two strains. The new owner of the kitten had lived in the apartment for some time before acquiring the kitten; therefore there could be no doubt of the kitten being the source of infection.

TREATMENT

Case I was given intensive and persistent treatment as soon as the cause of the trouble was definitely diagnosed. Daily baths and frequent shampoos were taken with medicated soap containing sulphur

or mercury compounds. The earliest treatment consisted in an application of a 5 per cent solution of salicylic acid in 95 per cent alcohol. The treatment was begun on April 18, and at first there seemed to be evidence of improvement, but about a week later the spots broke out again as small raised lumps around some of the old lesions. Additional new lumps developed even after the infection had run for some time. Treatment was continued once a day or twice when new lesions appeared. Some authorities insist that a 10 per cent solution of salicylic acid is necessary to kill the fungus, but this is very severe and many skins cannot tolerate so high a percentage. An application of $3\frac{1}{2}$ per cent solution of iodine was used quite faithfully for a few days, but the salicylic acid seemed to be more effective. On May 10, treatments were begun with bismuth violet,[3] made according to the following formula: 1 gram of bismuth violet crystals, 10 grams of salicylic acid, and 100 cc. of 70 per cent alcohol. This solution proved too strong, and the percentage of salicylic acid was reduced one-half. This treatment appeared quite effective, but on account of its color the solution is not desirable for ordinary use.

During the latter part of May treatment with an ointment of ammoniated mercury was begun, but as this was a salve it was applied only at night. On June 1, treatment was started with a certain commercial product. This was employed as a spray and was very convenient and satisfactory, as it could be applied several times a day and caused no discoloration. This medicinal spray appeared very effective, but just how much credit it should have is a question, because in all probability the fungus had been weakened or partly controlled by the applications of strong salicylic acid. It is important to repeat that, from the beginning, medicated soap was used regularly for both baths and thorough shampoos. The treatment of the kitten consisted of baths with a 1 per cent solution of orthophenylphenol in cocoanut oil soap. This treatment failed to control the fungus, which increased considerably and spread along the back and shoulders of the kitten. The long thick hair was doubtless partly responsible for the ineffectiveness of the treatment, but other factors entered into the case. The kitten was confined in a small cage in a hot room having a high degree of humidity. These two factors, heat and humidity, were especially favorable to the growth of the fungus. At the end of three weeks the kitten was taken to Pennsylvania by the original owner who reported that the kitten was finally cured, after having spent the summer out of doors.

[3] Formula patented by Dr. Irving S. Barksdale, Greenville, S. C.

DURATION OF THE DISEASE AND SUSCEPTIBILITY

The lesions of Case I were of long duration and great severity. The first spots appeared on April 16 and the spots continued to develop until early August. Even after that period, small red spots developed but soon subsided. During the course of the infection Case I developed over 70 typical lesions, the largest the size of a dime. In addition to the typical lesions, numerous small spots appeared which, however, soon yielded to treatment. Case II, another member of the household, developed lesions in considerable number but much less than Case I. In this instance a lesion developed in the scalp and was very slow in yielding to treatment. A third case was that of a friend who visited the house only once, on April 17, 1933, and held the kitten for several minutes. This case developed one very typical lesion on the neck, which was cured by the use of strong iodine.

There is evidently a great difference in the susceptibility of individuals. The original owner of the kitten had six cats in addition to the kitten so that there was every opportunity to develop a severe case of ringworm. These cats developed the disease but in a much milder form. No typical lesions appeared on the owner, but for some weeks she was troubled with rather hard, red, raised spots on her arms. These spots were too nearly cured when examined to make successful cultures even if the fungus had been the cause of the eruption.

The question of susceptibility or non-susceptibility has been attributed to various factors. E. W. and A. E. Stern[4] conducted experiments on the pH concentration of different remedies and showed that basic dyes are increasingly effective as inhibiting agents as the pH of the media is increased. Gentian violet is a basic dye that is effective, whereas mercurochrome is acid and has been found to be less effective. The question arose as to whether or not the degree of acidity or alkalinity of the human system would have any bearing on the question of susceptibility. Hoping to get a little data on this phase of the subject, a series of experiments was conducted with culture media having different pH concentrations ranging from 4.7 to 7.3. The cultures were fairly uniform in growth, no marked differences being observed.

DETERMINATION AND MORPHOLOGY OF THE CAUSAL ORGANISM

The mycelium observed in the scrapings from the human skin lesions and in the scurf from the kitten was found very sparingly and

[4] STEARN, E. W. and A. E. Journ. Lab. & Clin. Med. **14**: 1057–1060. 1927.

was hyaline and fine, about $2\frac{1}{2}$ to 3μ in diameter. In the cultures the mycelium was much coarser. The cultures produced spores in great abundance in 3 days. From the spores the fungus was determined as a species of *Microsporum*.

Two species of this genus, *M. lanosum* Sabouraud[5] and *M. felineum* Fox and Blaxall[6] have been reported as occurring on cats. *Microsporum lanosum* or *Microsporum caninum* Bodin was first observed on dogs, but later reported on cats. *Microsporum felineum* was investigated first by Fox and Blaxall in 1896, who described the transmission of the ringworm from cat to man, but did not name the fungus specifically. This species was reported of frequent occurrence in England but was not found in Paris. Later, in 1902, it was found by Mewborn[7] in New York. The author's use of the name *Microsporum felineum* appears to be the first time it was mentioned in literature. These two species have been considered identical by different authorities, and there is nothing in the descriptions of the microscopic characters of the species to separate them.

The organism studied in the present investigation has been tentatively referred to *M. felineum*. Because of the marked variation observed in the size and shape of the spores in cultures isolated from cats, in the same strains at different ages, and in cultures inoculated into cats and later recovered and re-cultured, it is felt that until a comparative study is made of a large number of strains isolated from cats a specific determination cannot be positive. Comparative examinations were made of strains from cats from Texas, District of Columbia, and New York. The three strains showed a wide range in the spore measurements. The strain from Texas grew slowly and produced smaller, narrower spores than those of the local strain studied by the authors, while the New York strain had spores over twice as long as the latter strain and narrower. In strains from Texas and District of Columbia, the cell walls were not conspicuously muriculate and then only at an advanced stage. The strain from New York showed this character earlier and in a much more marked degree. It is observed that the spores of the organism studied here exceed the measurements for *M. felineum*, but in the different strains studied the size of the spores seemed to vary so much, according to age and vigor, that these differences were not considered sufficiently constant to warrant the establishment of a new species.

[5] SABOURAUD, R. *Trichophyties Humaines.* Atlas, p. 58. Paris. 1907.
[6] FOX, C. and BLAXALL, F. R. Brit. Journ. of Dermatology **8**: 377–384. 1896.
[7] MEWBORN, A. D. New York Medical Journal **76**: 843–849. 1902.

Cultures made from the scrapings of the human skin and from the scurf of the cat, on Sabouraud and corn meal agar, grew rapidly and fruited in 3 days. The cultures were at first white and fluffy, but later became powdery and deep cream in color. In Petri dishes the fungus showed marked zonations and a tendency to make a secondary growth. The spores were hyaline, spindle-shaped, mostly 7 to 9-septate, and ranged in size from $8–12\mu \times 45–60\mu$. Old cultures were strikingly pleomorphic and showed an abundance of chlamydospores and so-called aleurispores. No striking morphological differences were apparent in cultures made from the inoculated cats.

It is proposed to assemble various strains of *Microsporum* occurring on cats widely separated geographically in order to make a comparative study of these forms.

PALEOBOTANY.—*A walnut from the Chesapeake Miocene.*[1] EDWARD W. BERRY, Johns Hopkins University.

Fossil plants are extremely rare in the shallow water marine formations of the Middle Atlantic Miocene and, as far as I know, are confined to a very few localities where the near shore deposits of the Calvert—the basal formation of the Chesapeake group—have yielded a limited number of species.

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Fig. 1. *Juglans calvertiana* Berry of Calvert formation, 1½ miles south of Plum Point, Maryland.
Fig. 2. *J. calvertiana* from Richmond, Virginia.

An attempt was made to evaluate these florules in 1916[2] and it was concluded that the one from the District of Columbia with its small-leafed oaks, holly, *Vaccinium, Pieris* and Leguminosae represented a temperate flora growing in a region of coastal sand dunes on a low coast with high insolation and slight run-off; and that from Richmond, Va., indicated a low coast lined with cypress swamps where the inconsiderable run-off carried only the finest muds. This past summer

[1] Received Dec. 16, 1933.
[2] BERRY, E. W. *The physical conditions indicated by the flora of the Calvert formation.* U. S. Geol. Survey Prof. Paper **98**: 61–73, *pls. 11, 2.* 1916.

Dr. R. L. Collins collected a single compressed nut from Zone 11 of the Calvert formation[3] at a locality 1½ miles south of Plum Point, on the Bay shore in Calvert County, Md. This was collected in place from near the base of Zone 11 which is here a poorly fossiliferous sandy clay about 13 ft. thick, at a point where recent storm waves had washed a new face at the base of the cliff.

At about the same time Mr. Benjamin Gildersleeve working for the Virginia Geological Survey, collected a second specimen from an exposure in the bed of Cannon Creek, 100 ft. north of the Valley road in the city of Richmond, Va. This second specimen was partly weathered out of the matrix and is in two pieces, which enables one to get some idea of the internal morphology.

Although it is not desirable to sacrifice the Maryland specimen to check the internal features, the size, degree of compression, degree of lignification and rather characteristic surface ornamentation leave no doubt that the two fossils represent a nut of the same botanical species and that the internal features of the Virginia specimen may safely be used to amplify the description of the species.

There can be no doubt but that we are dealing with the fruit of some member of the family Juglandaceae and the shape and rugose surface of the specimens point to the genus *Juglans* rather than to *Hicoria*. The seed itself is too shriveled to furnish positive evidence, but the proportions and size of the seed cavity point in the same direction as do the external features.

The species may be called *Juglans calvertiana* and is the first Miocene species from eastern North America. It may be described as follows:

Juglans calvertiana n.sp.

Nut indehiscent, bony, apparently circular in cross-section, with no evidence of any angularities; slightly prolate-spheroidal in form; slightly apiculate—a feature which may have been more pronounced in life than the specimens indicate; rounded at the base; medium thick-walled, irregularly longitudinally rugose, the rather flattened rugosities formed by inosculating and rather deep sulcae.

Seed solitary, fleshy, deeply two-lobed, prominently pointed, too shrunken to show whether it was corrugated as in *Hicoria* or more smoothly excavated as in *Juglans*, seemingly less compressed than in *Hicoria* and with the general proportions of the seeds of *Juglans*.

		Maryland specimen	Virginia specimen
Dimensions:	Length	2.1 cm.	2.05 cm.
	Width	1.8 cm.	1.8 cm.
	Thickness	0.9 cm.	1.3 cm.

[3] Maryland Geol. Survey. Miocene, p. lxxii, 1904.

Regarding the ecological meaning of the specimen a species of *Juglans* hardly fits into the picture of a dune flora or a cypress swamp association, which, as previously mentioned were considered to be the associations of the District of Columbia and Richmond florules respectively.

Insofar as climatic features are concerned *Juglans* accords well with the idea of a temperate flora during the deposition of the Chesapeake group Miocene. That this walnut was not a coastal species, but was carried into the basin of sedimentation by river action seems probable, and while it is remarkable that two specimens from widely separated regions should be found at the same time, the fact that nothing of the sort has hitherto been encountered in all the years that the Calvert exposures have been assiduously collected over by both vertebrate and invertebrate paleontologists points to the actual rarity of such remains and further enhances the probability of the foregoing explanation.

The genus *Juglans* has a fossil record which according to the published accounts goes back to the Mid-Cretaceous and about 150 nominal extinct species have been described. Sixteen Upper Cretaceous species, all from North American localities and all based upon leaflets have been described, but the majority of these must be considered of doubtful botanical validity as the identity of none of the leaflets is confirmed by fossil fruits. The fossil fruits are found however, often in some abundance, in formations ranging in age from the Eocene to the present.

About a dozen Paleocene species are recorded, all North American and all open to some question, and about 26 Eocene all North American or Arctic, except a single European form. The majority of these are based upon leaflets but several fruits have also been found. Oligocene species to the number of 15 have been described and these are all European except one based upon entirely characteristic petrified seeds from the *Titanotherium* beds of Dakota. The absence of North American Oligocene records is to be attributed to the actual dearth of, and the failure to recognize beds of this age on this continent and not to any absence of the genus at that time in North America.

More than 50 Miocene species have been described, the majority of which are European, but Asia, Porto Rico and northern South America appear in the record at this time and many are represented by characteristic fruits. The 14 North American Miocene species are all from the western part of the continent.

About 20 Pliocene species are known, mostly European, although several are from Asia and include many excellent and characteristic fruits. North America does not contribute to the Pliocene record and, as in the Oligocene, this is due to the sparsity of Pliocene deposits which are either marine or are in the arid western part of the continent. Pleistocene species, several of which are apparently extinct, are found in Europe (2), Asia (1), North America (4), and Porto Rico (1). The majority of these are based upon fruits.

ORNITHOLOGY.—*Bird bones from old Eskimo ruins in Alaska.*[1]
HERBERT FRIEDMAN, U. S. National Museum.

In the past few years several valuable lots of Alaskan avian bones have come to the United States National Museum as a by-product of explorations and excavations by members of the Divisions of Anthropology and Ethnology. For convenience in publication and reference, the reports on these collections have been combined into one paper, but each is treated separately herein.

It has been argued at times that bird bones found in old Eskimo habitations are not reliable faunal records as they might have been brought there from quite far off by visiting Eskimos. This, however, is largely negatived by the sedentary habits of almost all the present tribes and village groups of these people.

Not only do these bones (which total hundreds of individual specimens) reveal a little of the "third-dimension" of avian geography, that is, the time duration of present local distribution, but they also yield a number of interesting distributional records, as well as supplying information on the diet of the Eskimos in prehistoric times.

ANCIENT BIRD BONES FROM AMAKNAK ISLAND, ALEUTIAN ISLANDS

The bones reported on below were collected by Mr. Henry B. Collins, Jr., Assistant Curator of Ethnology of the United States National Museum from three ancient Eskimo village sites on Amaknak Island. The exact age of the sites (and therefore of the bones) is not determinable, but according to Mr. Collins their antiquity is very considerable, probably over a thousand years. The village sites are designated by their relative positions—West, East, and Southwest.

Amaknak Island is a small island in Unalaska Bay near the entrance of Captain's Bay, in the northeastern part of Unalaska Island, in the central part of the Aleutian chain. It has a port, Dutch Harbor, where the ships bound for Unalaska generally call, but it has not figured in ornithological literature under its own name to any extent, practically all bird records from there having been recorded merely as "Unalaska Island."

The bones include identifiable remains of 21 species. The majority of these are well known members of the Aleutian, or even Unalaskan, avifauna; two, the yellow-billed loon and the long-tailed jaeger, are of interest as geographic records. Of the bones collected, those in

[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 2, 1934.

sufficiently good condition to be useful as specimens have been retained in the national collections, the fragmentary specimens (unless of interest as records) have not been kept in all cases. An annotated list of the species follows.

GAVIA ADAMSI (Gray) Yellow-billed Loon

The yellow-billed loon is represented by a metacarpal and a tarsometatarsus found in the diggings in the East Village. This species appears to be new to Unalaska Island.

GAVIA STELLATA (Pontoppidan) Red-throated Loon

Two fragmentary humeri were found at the East Village.

DIOMEDEA ALBATRUS Pallas Short-tailed Albatross

A coracoid from the South West Village site (two to three feet down from the surface), and several fragmentary humeri from the East Village (surface down to six feet below) represent this albatross.

PUFFINUS TENUIROSTRIS (Temminck) Slender-billed Shearwater

The slender-billed shearwater is represented by a coracoid found in the surface diggings at South West Village.

PHALACROCORAX PELAGICUS PELAGICUS Pallas Pelagic Cormorant

Two humeri and a fragmentary tarsometatarsus from East Village, a coracoid from West Village, and several humeri and a tibiotarsus from South West Village (surface to three feet deep) reveal the presence of this cormorant on Amaknak Island.

ANSER ALBIFRONS subsp. White-fronted Goose

The white-front goose (probably *gambeli*) is represented by a broken humerus found in the superficial diggings at East Village.

CLANGULA HYEMALIS (Linnaeus) Old-Squaw

One humerus of the old squaw was found at West Village.

HISTRIONICUS HISTRIONICUS PACIFICUS Brooks
Western Harlequin Duck

The western harlequin duck is represented by a humerus from the superficial layer at South West Village, and by another from the deepest layer (four to six feet) at East Village.

Somateria v-nigra Gray Pacific Eider

The Pacific eider is represented by bones from three village sites—a tibiotarsus from West Village, a broken tarsometatarsus from South West Village (layer two to three feet deep), and by fragments from East Village (layer three to four feet deep).

Somateria spectabilis (Linnaeus) King Eider

Four fragmentary coacoids from East Village, an ulna from South West Village (superficial layer), and a humerus from the deepest layer (four to six feet) from North East Village belong to this species and indicate the relative commonness of the king eider at Amaknak.

Melanitta deglandi (Bonaparte) White-winged Scoter

The white-winged scoter is represented by a broken humerus from West Village, four humeri from East Village, and two humeri from the superficial layer of North East Village.

Oidemia americana Swainson American Scoter

A tarsometatarsus from the middle layer (three to four feet deep) from East Village is of this species.

Haliaeetus leucocephalus alascanus Townsend Northern Bald Eagle

A broken humerus and a tarsometatarsus from South West Village belong to the Northern bald eagle.

Stercorarius parasiticus (Linnaeus) Parasitic Jaeger

The parasitic jaeger is represented by a humerus and a tarsometatarsus from East Village, and by a broken tibiotarsus from the deepest layer (four to six feet) from East Village.

Stercorarius longicaudus Vieillot Long-tailed Jaeger

The long-tailed jaeger is represented by five pairs of humeri and one tarsometatarsus from East Village, two humeri and three fragmentary tarsometatarsi from South West Village (surface to three feet deep), and by six humeri (two pair plus two) from West Village.

LARUS HYPERBOREUS Gunnerus Glaucous Gull

A humerus from East Village and a mandible from the middle layer (three to four feet) from East Village represent the glaucous gull.

LARUS GLAUCESCENS Naumann Glaucous-winged Gull

The glaucous-winged gull is represented by a fragmentary humerus from the lowest layer (four to six feet) from East Village.

URIA AALGE CALIFORNICA (Bryant) California Murre

The California murre is listed here on the basis of two humeri from South West Village (two to three feet deep), and a piece of a skull, a humerus, and some fragments from the two lower layers (three to six feet deep) from East Village. This species is very similar to the next osteologically and a number of bones have been considered unidentifiable and are omitted from this report.

URIA LOMVIA ARRA (Pallas) Pallas's Murre

The Pallas's murre is represented by two broken humeri from West Village, a coracoid, two humeri, two femurs, two fragmentary pairs of clavicles, and three ulnae from South West Village (superficial layer), and by nine humeri and three ulnae from East Village. If Salomonsen's new form *inornata*[2] be recognized, these bones would have to be considered as of that race, a course that I consider not unlikely.

CEPPHUS COLUMBA Pallas Pigeon Guillemot

A few fragments of pigeon guillemot bones were found in the superficial layer at South West Village.

LUNDA CIRRHATA (Pallas) Tufted Puffin

The tufted puffin is represented by a humerus and an ulna from East Village.

BIRD BONES FROM OLD ESKIMO RUINS ON KODIAK ISLAND

The following bird bones were collected by Dr. Ales Hrdlicka, curator of Physical Anthropology, United States National Museum, in old Eskimo ruins on Kodiak Island, Alaska, during the summer of 1932. The bones are all in the collections of the Museum.

[2] Ibis, 1932, p. 128: St. Matthew's Island, Bering Sea.

GAVIA IMMER ELASSON Bishop   Lesser Loon

One humerus of this loon was collected. The subspecific determination is made on the basis of geography.

COLYMBUS GRISEGENA HOLBOELLI (Reinhardt)   Holboell's Grebe

This species is represented by a single humerus.

DIOMEDEA ALBATRUS Pallas   Short-tailed Albatross

A tarsometatarsus represents this species in the present collection.

FULMARUS GLACIALIS RODGERSI Cassin   Pacific Fulmar

One fractured skull of this bird was unearthed.

PHALACROCORAX CARBO SINENSIS (Shaw and Nodder)
Chinese Cormorant

A humerus of this species (subspecies by virtue of geography) is the most surprising discovery in this collection. It comprises not only a great eastern extension of range of this cormorant, but also the first record for the form in North America.

PHALACROCORAX PELAGICUS PELAGICUS Pallas   Pelagic Cormorant

The pelagic cormorant is represented by five good and two fragmentary humeri, two ulnae, and one tibiotarsus.

ANSER ALBIFRONS ALBIFRONS (Scopoli)   White-fronted Goose

The white-fronted goose is represented by a single humerus in almost perfect condition.

CHEN ROSSI (Cassin)   Ross's Goose

A fragmentary skull exactly matches one of this species. This bird appears to be new to the avifauna of Kodiak Island.

CLANGULA HYEMALIS (Linnaeus)   Old-squaw

One sternum of this form was collected.

SOMATERIA V-NIGRA Gray   Pacific Eider

A single coracoid and two skulls of this eider were collected.

SOMATERIA SPECTABILIS (Linnaeus) King Eider

A humerus and seven skulls of this bird were brought back by Dr. Hrdlicka.

ARCTONETTA FISCHERI (Brandt) Spectacled Eider

This duck is represented by a humerus. It is known to winter in the Aleutian chain and southward.

MELANITTA DEGLANDI (Bonaparte) White-winged Scoter

Nine humeri and three ulnae of this bird were collected.

MELANITTA PERSPICILLATA (Linnaeus) Surf Scoter

Of this species five humeri and two ulnae were found.

OIDEMIA AMERICANA Swainson American Scoter

This duck is represented by a broken skull, fifteen humeri, and two ulnae.

HALIAETUS LEUCOCEPHALUS ALASCANUS Townsend
Northern Bald Eagle

The bald eagle is one of the commonest birds of Kodiak Island, and its remains are similarly numerous. It is represented in this collection by nine skulls in various degrees of perfection, one pair of mandibles, four sterna, seven synsacra, thirteen humeri, four ulnae, two radii, five tibiotarsi, two coracoids, one clavicle, one femur, three tarsomettatarsi, and twelve metacarpals.

LAGOPUS RUPESTRIS KELLOGGAE Grinnell Kellogg's Ptarmigan

A single humerus of this bird was brought back by Dr. Hrdlicka. The subspecific identification is based on Taverner's data on the distribution of the races of the rock ptarmigan (Ann. Rept. Nat. Mus. Canada 1928: 28–36).

LARUS HYPERBOREUS Gunnerus Glaucous Gull

This gull is represented by four humeri.

LARUS GLAUCESCENS Naumann Glaucous-winged Gull

Five humeri of this gull were collected.

Uria aalge californica (Bryant) and Uria lomvia arra (Pallas) California Murre and Pallas's Murre

It is unfortunate that the bones of these two murres are not more diagnostic as both species occur on Kodiak Island. The genus is represented by four skulls, five synsacra, one pair of clavicles, one pair of maxillae, one femur, one ulna, two tibiotarsi, and twenty-three humeri. The probabilities are that the majority of the bones are of *Uria lomvia arra* as that is the commoner of the two murres on the Island.

Cepphus columba Pallas Pigeon Guillemot

A single skull represents this bird in the present collection.

Bubo virginianus algistus (Oberholser) Saint Michael Horned Owl

Dr. Hrdlicka collected six ulnae of a great horned owl, which on geographical grounds, is probably the race *algistus*. It is rather strange that no other parts of the skeleton were found.

Surnia ulula caparoch (Müller) American Hawk Owl

A single fragmentary skull represents this species.

Corvus corax principalis Ridgway Northern Raven

This raven is represented by four skulls, one pair of maxillae, two humeri, and two ulnae.

Corvus brachyrhynchus caurinus Baird Northwestern Crow

A single humerus of this crow was collected.

BIRD BONES FROM CAPE DENBEIGH, NORTON SOUND

These bones were collected by Mr. H. B. Collins, Jr., from diggings of prehistoric, but probably not very ancient, Eskimo ruins at Cape Denbeigh. The great bulk of the bones are of two species of ptarmigan, *Lagopus rupestris* and *Lagopus lagopus*, both of which were obviously the chief avian items of food (and probably still are) of the local Eskimos. The next most abundant bones are those of Pallas's murre, *Uria lomvia arra*, the white winged scoter, *Melanitta deglandi*, and the Pacific and King eiders, *Somateria v-nigra* and *Somateria spectabilis*. Fifteen species in all are represented in the Cape Denbeigh material, a list of which is as follows:

Gavia adamsi (Gray)	Yellow-billed Loon
Gavia stellata (Pontoppidan)	Red-throated Loon
Phalacrocorax urile (Gmelin)	Red-faced Cormorant
Branta canadensis minima Ridgway	Cackling Goose
Histrionicus histrionicus pacificus Brooks	Western Harlequin Duck
Somateria v-nigra Gray	Pacific Eider
Somateria spectabilis (Linnaeus)	King Eider
Melanitta deglandi (Bonaparte)	White-winged Scoter
Melanitta perspicillata (Linnaeus)	Surf Scoter
Oidemia americana Swainson	American Scoter
Logopus lagopus alascensis Swarth	Alaska Ptarmigan
Lagopus rupestris subsp.	Rock Ptarmigan
Uria lomvia arra (Pallas)	Pallas's Murre
Cepphus columba Pallas	Pigeon Guillemot
Fratercula corniculata (Naumann)	Horned Puffin

BIRD BONES FROM SEWARD PENINSULA

In 1929 Mr. H. B. Collins, Jr., excavated an old Eskimo village at Kowieruk, three miles east of Imaruk Basin, Seward Peninsula. This site was poor in bird bones but revealed fragments of three species:

Gavia adamsi (Gray)	Yellow-billed Loon
Clangula hyemalis (Linnaeus)	Old-squaw
Histrionicus histrionicus pacificus Brooks	Western Harlequin Duck

BIRD BONES FROM BONASILA

In the course of some diggings in an old midden at Bonasila Dr. Hrdlicka unearthed a few bird bones representing the following three species.

CYGNUS COLUMBIANUS (Ord) Whistling Swan

Two broken humeri and one femur.

BRANTA CANADENSIS MINIMA Ridgway Cackling Goose

One humerus and one femur.

MELANITTA DEGLANDI (Bonaparte) White winged Scoter

One humerus.

SCIENTIFIC NEWS AND NOTES

Prepared by Science Service

NOTES

Meeting of the American Chemical Society.—At the spring meeting of the American Chemical Society, held in St. Petersburg, Florida, March 26 to 30, papers were presented by the following Washington scientists: J. E. Adams, Bureau of Chemistry and Soils; George M. Bahrt, Bureau of Chemistry and Soils; Frederick Bates, Bureau of Standards; F. G. Brickwedde, Bureau of Standards; C. A. Browne, Bureau of Chemistry and Soils; C. K. Clark, Bureau of Chemistry and Soils; C. C. Concannon, U. S. Department of Commerce; J. M. Dallavalle, U. S. Public Health Service; E. L. Demmon, Forest Service; P. H. Emmett, Bureau of Chemistry and Soils; E. J. Fox, Bureau of Chemistry and Soils; W. A. Gersdorff, U. S. Department of Agriculture; R. E. Gibson, Carnegie Institution of Washington; R. M. Hann, National Institute of Health; R. W. Harkness, Bureau of Chemistry and Soils; T. H. Harris, Bureau of Chemistry and Soils; H. P. Holman, Bureau of Chemistry and Soils; C. S. Hudson, National Institute of Health; H. S. Isbell, Bureau of Standards; E. F. Kohman, National Canners Association; C. H. Kunsman, Bureau of Chemistry and Soils; H. H. Mottern, Bureau of Chemistry and Soils; E. K. Nelson, Bureau of Chemistry and Soils; E. M. Nelson, Bureau of Chemistry and Soils; R. A. Nelson, Bureau of Chemistry and Soils; S. Palkin, Bureau of Chemistry and Soils; G. N. Pulley, Bureau of Chemistry and Soils; C. B. Purves, National Institute of Health; D. A. Reynolds, Bureau of Mines; N. H. Sanborn, National Canners Association; R. R. Sayers, U. S. Public Health Service; W. C. Smith, Bureau of Chemistry and Soils, F. H. Thurber, Bureau of Chemistry and Soils; J. W. Turrentine, Bureau of Chemistry and Soils; H. W. Von Loesecke, Bureau of Chemistry and Soils; J. R. Winston, Bureau of Plant Industry, and W. P. Yant, U. S. Public Health Service.

Johns Hopkins University.—The university circular covering 1934 summer courses announces the following Washington scientists as special lecturers for the Summer Research Conferences on Chemical Physics: F. G. Brickwedde, Bureau of Standards; and S. B. Hendricks and L. R. Maxwell, Bureau of Chemistry and Soils.

The Hillebrand prize.—The Hillebrand prize of the Chemical Society of Washington for the year 1933 has been awarded to the late Dr. Edward Wight Washburn for the discovery of the first practical method of separating the isotopes of hydrogen. This discovery, namely, the electrolytic method of separation, has made possible the subsequent research into the properties of the isotopes of hydrogen, and has thus initiated almost a new era in chemistry, consequent upon the differences in the chemical and physical properties of these isotopes and their compounds.

Biological Survey.—Dr. Jay N. Darling on March 19 took the oath of office as chief of the Bureau of Biological Survey, U. S. Department of Agriculture. Early this year he was awarded the Medal of the Outdoor Life Magazine for outstanding service in the field of wild-life conservation. On June 14, 1933, he was appointed by Secretary Wallace as a member of the

Advisory Board, Migratory Bird Treaty Act. He has also served as a member of the President's Committee on Wild-Life Restoration.

A recently revised map of the Canadian northwest designates a hitherto unnamed bay on Great Bear Lake as Preble Bay, in honor of E. A. PREBLE of the Bureau of Biological Survey, an early explorer of this region. Mr. Preble had previously been similarly honored when an island 25 miles long in Great Slave Lake was named Preble Island. In North America Fauna No. 27, "A Biological Investigation of the Athabaska-Mackenzie Region," published by the Bureau in 1908, Mr. Preble not only provided the first extensive biological knowledge of this region but also made important contributions to its geography.

Dr. W. B. BELL spoke before a Recreation Conference held March 16 to 18 at the Massachusetts State College, in Amherst, on "The Biological Survey's Contribution to Recreation."

On March 3, F. C. LINCOLN, of the Bureau of Biological Survey, spoke at the annual meeting of the Wilderness Club at Philadelphia, Pa., on *The distribution and migration of some eastern waterfowl.* Mr. Lincoln was recently appointed one of five members of the Waterfowl Committee of the National Association of Audubon Societies.

Bureau of Standards.—Dr. RALEIGH GILCHRIST left on March 14 to attend international congresses on chemistry in Paris and Madrid, as official delegate of the Department of Commerce and of the National Research Council. At the Madrid congress he presented a paper by himself and Dr. E. WICHERS, also of the Bureau's staff, on *A new system of analytical chemistry for the platinum metals.*

Children's Bureau, Department of Labor.—An extensive program has been undertaken for the location of children who are undernourished or in need of medical care. This was first suggested at a national conference called last fall after information assembled by the Children's Bureau had shown many children to be showing effects of the depression. With the aid of C.W.A. funds, thirty-eight states and Puerto Rico set up child health nursing services and employed approximately 2,300 nurses, including 180 supervisors. The Bureau has made available the services of five physicians to assist the states in the development of the program and has prepared special examination forms for use by physicians making examinations of children suspected of being undernourished.

In a majority of the states the lead in organizing the child health recovery program was taken by the state health departments, in a few by the state medical associations, the Academy of Pediatrics, or the state relief administrations. Support of the work has been voted by the American Child Health Association, which lent the part-time services of its medical director for three months, and by the executive board of the American Academy of Pediatrics. Lay organizations of men and women are also assisting.

Department of Terrestrial Magnetism, Carnegie Institution.—R. H. MANSFIELD, who has been stationed at the Huancayo Magnetic Observatory in Peru since September 26, 1932, left the Observatory the latter part of April for Buenos Aires whence he will proceed to Capetown, South Africa. After comparing instruments at the University of Capetown, he will make his way up the east coast of Africa to Aden, Port Sudan, and Suez, securing en route magnetic observations at selected stations previously occupied by observers of the Carnegie Institution of Washington. The principal object of this ex-

pedition is to obtain data for the study of secular variation in the region traversed.

O. W. TORRESON accompanied by Mrs. TORRESON, left Washington on April 6, 1934, for Peru, where he will join the staff of the Huancayo Magnetic Observatory.

Dr. B. J. F. SCHONLAND, Senior Lecturer in Physics, University of Capetown, South Africa, and well known for his investigations of lightning, arrived in New York on April 8, for a ten-week visit in the United States. He plans to spend the first six weeks at the Department of Terrestrial Magnetism. He is to present several papers on the results of some of his recent work at the scientific meetings which will be held in Washington the latter part of April. Before his departure in June, he will visit a number of universities and scientific institutions in the eastern and middle-western states.

Bureau of Fisheries.—At the invitation of the deputy governor of the Federal Reserve Bank of Philadelphia, JOHN S. SINCLAIR, Dr. P. S. GALTSOFF, in charge of oyster investigation for the United States Bureau of Fisheries, presented at the meeting called by the reserve bank, March 27, 1934, an analysis of the present conditions in the oyster industry with special reference to New Jersey.

Dr. GALTSOFF regards the drop in demand for oysters and low prices as being responsible for the present critical situation. Planting operations in Delaware Bay begin in May and end on June 30, but on account of the general economic situation and especially because of the closure of several local banks, the oystermen are unable to obtain credit to finance planting operations. Steps are being taken to obtain credit from the Federal reserve bank.

The sound policy, adopted by the state in maintaining the public seed oyster beds from which planters are permitted to dredge seed oysters for cultivation, is a guarantee that natural oyster resources of the state will not be depleted. This conclusion is corroborated by the fact that from 1880 until 1929 oyster production in New Jersey steadily increased, whereas, in the Chesapeake Bay it materially declined.

At the request of the New York State Conservation Commissioner, LITHGOW OSBORNE, a conference was held by the representatives of the state and officers of the United States Bureau of Fisheries at Cambridge, Mass., on March 21, for the purpose of laying plans for a cooperative investigation of the marine fisheries of New York. As a result of the very definite increase in interest among anglers, particularly in the fishery resources of the marine district, the conservation department is considering the possibility of undertaking an intensive study of the fish supply in order to provide for adequate utilization as well as conservation. Dr. EMMELINE MOORE, chief aquatic biologist of the conservation department, presented the tentative plans of the state's investigation, and R. A. NESBIT, in charge of the Bureau's investigations in the Middle Atlantic section, discussed at length the findings of four years of research by himself and several assistants in this field.

PERSONAL ITEM

DELBERT M. LITTLE, for the past five years in charge of the Weather Bureau's station at Oakland, Calif., has been promoted to the chief of the aerological division of the Bureau.

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Vol. 24 June 15, 1934 No. 6

PALEONTOLOGY.—*Early Tertiary species of gastropods from the Isthmus of Tehuantepec.*[1] JULIA GARDNER, U. S. Geological Survey and EDGAR BOWLES, Johns Hopkins University.

Among some collections made in Mexico a number of years ago, was a small gastropod assemblage of four species, all of them unfamiliar. They had nothing in common with any known East Coast or Gulf fauna and were put aside in the hope that at some future time check material might come to light. A few months ago, in a random survey of the Federal collections, Mr. F. E. Turner of the University of California came upon them and commented on their extraordinary resemblance to middle Eocene (Domengine) species from the Simi Valley in southern California. A closer comparison further revealed the faunal similarity which is the more significant because the species are not generalized but are apparently specialized and short ranging types. Although certain elements in the Domengine fauna are present in the Umpqua formation of Oregon, there is no former record of the extension of the Domengine sea south of California. So close, however, is the resemblance between the Chiapas faunule and that from the Simi Valley, distant more than 1700 miles in an air line, that a common shore line may be reasonably postulated.

The Chiapas locality is about 12 miles east-north-east of Sayula and less than 10 miles behind the mountain front which faces the Atlantic Ocean. There is no evidence in the present material that the Atlantic had broken through, but the inter-oceanic barrier must have been extremely narrow.

The sketch map (Fig. 1) indicates the outcrop from which the collection was made.

[1] Published by permission of the Director, U. S. Geological Survey. Received March 5, 1934.

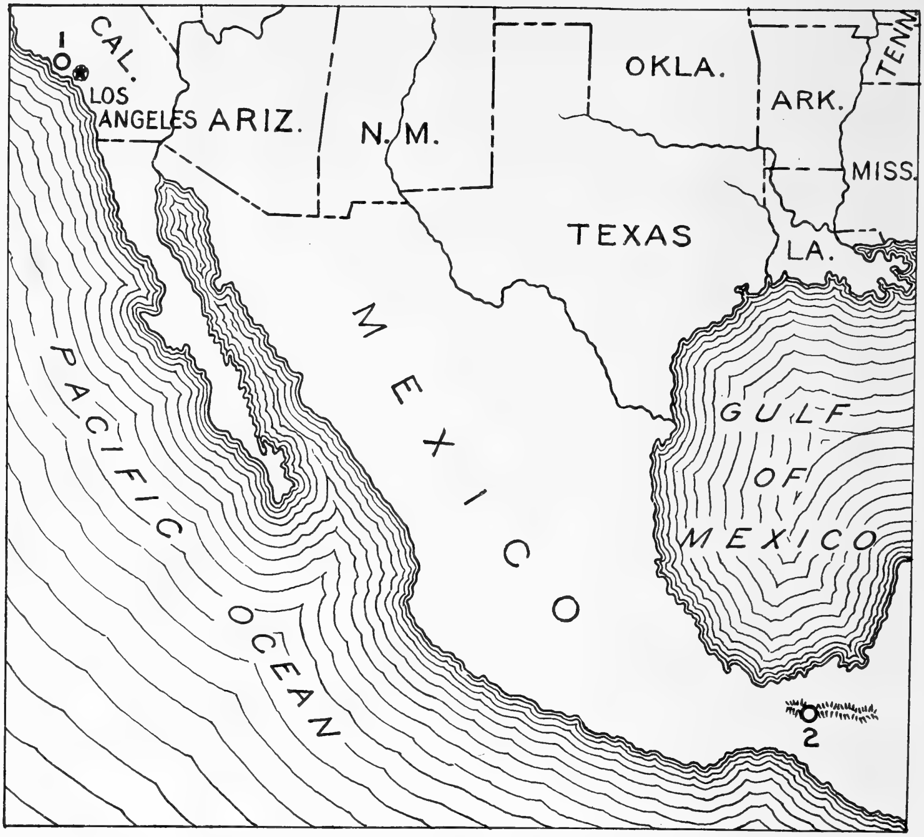


Fig. 1.—Locality 1—Simi Valley, California; 2—12 miles east-north-east Sayula, Chiapas, Mexico.

AMPULLINAE

Cernina Gray

1840. Gray, J. E. Syn. Cont. Brit. Mus., **42**: 147.

Type: *Natica fluctuata* G. B. Sowerby (Recent in the south Pacific).

The type of *Cernina* is a large, not very heavy, inflated shell with a depressed spire and with a widely expanded and obliquely produced aperture. The inner margin of the aperture is broadly constricted at the base of the body. The parietal callous is very heavy but thins gradually and is spread over the body wall with no sharply defined limit excepting at the extreme anterior portion where it merges into the sharp, narrowly reverted, anterior margin of the aperture. The genotype is the only living representative of a family which was widespread during the first half of the Tertiary, both in

the Tethyan sea and in the cooler waters. Stewart[2] in his discussion of the Ampullinae recognized the need of a new group name to include "*Natica*" *hannibali* Dickerson: "*Globularia hannabali* Dickerson might be cited as an Eocene *Cernina* but it has a much heavier callous extending over the parietal region with a distinct boundary. I think it will prove to represent a separate group of *Globularia*, not directly related to *Cernina*, the latter having probably developed from Globularia in the Miocene or later." The importance of the group is increased by the recognition of an allied member many hundred miles to the south of the form described by Dickerson.

EOCERNINA Gardner and Bowles, new section

Type: *Natica hannabali* Dickerson. Middle Eocene (Umpqua formation) of Oregon.

Shell heavy; obliquely ovate. Spire depressed. Nucleus not preserved but certainly small and paucispiral. Post nuclear whorls increasing very rapidly in diameter. Aperture pyriform, expanded and obliquely produced anteriorly, the line of division between the outer lip and the parietal callous indicated by a shallow groove. Parietal callous heavy with a sharply defined outer limit, almost or entirely sealing the umbilicus and merging into the slightly reverted anterior margin of the aperture. Sculpture restricted to incrementals with occasional resting stages.

The section is founded upon the type species from the Umpqua formation of Oregon and its variants in the Domengine formation of southern California and a new species from the Isthmus of Tehuantepec.

Ampullina sphaerica Deshayes from the upper Eocene of the Paris Basin shares with the American forms the depressed spire, heavy shell, and parietal callous.

Cernina (Eocernina) **chiapasensis** Gardner and Bowles, n. sp.
Fig. 2, 3.

Shell subglobose, smoothly inflated; spire depressed. Nuclear whorls not preserved but doubtless small in size and few in number. Post-nuclear whorls 4 to 5, increasing rapidly in diameter; body whorl largely enveloping the earlier volutions, inflated, obtusely shouldered. Sculpture consisting only of fine incremental lines, most evident on the body whorl. Sutures regular, clearly defined, and deeply impressed. Aperture wide and flaring, anteriorly produced. Parietal callous heavy. Umbilicus almost or entirely covered by the encroaching callous.

Dimensions: Height, 36 millimeters; greatest diameter, 38$\pm$millimeters (aperture of specimen incomplete).

Holotype: U. S. National Museum No. 373046.

Paratype: U. S. National Museum No. 373047.

Type locality: U. S. Geol. Survey Sta. No. 13230, about 12 miles east-north-east of Sayula, Chiapas, Mexico. Eocene.

The closest analogue of this species is *Ampullina hannibali* Dickerson[3] from

[2] STEWART, R. B. Acad. Nat. Sci. Philadelphia, Proc. **78**: 331. 1926.

[3] DICKERSON, R. E. California Acad. Sci. Proc., ser. 4, **1**: no. 4, p. 119. *pl. 12, figs.* 5*a*, 5*b*. 1914. (as *Natica hannibali*).

the middle Eocene (Umpqua formation) of Oregon, and the variants in the Domingine of the Simi Valley, California. The West Coast species differs from *A. chiapasensis*, however, in its less inflated and more obliquely shouldered body whorl; its higher spire; its more flaring aperture; and the heavier callous which completely seals the umbilicus. The apparent perforation in the umbilicus of the holotype is, however, increased by the broken margin of the callous.

Cerina chiapasensis is represented by the holotype and a smaller paratype, measuring 28 millimeters in height and 26.5 millimeters in maximum diameter.

AMAURELLINA "Bayle" Fischer 1885

1885. Fischer, Paul, Manuel de Conchyliologie. 8: 766. 1885..

Type by monotypy: *Ampullaria spirata* Lamarck. Eocene of the Paris Basin.

Amaurellina malinchae Gardner and Bowles, n. sp.

Fig. 5.

Shell of medium size. Spire more than one-third as high as the entire shell; scalariform. Nuclear whorls not well preserved or clearly differentiated from the conch. Post-nuclear whorls probably 5 in number, regularly increasing in size, those of the spire rudely trapezoidal in outline. Body whorl angular posteriorly, elongated and tapering anteriorly. Shoulders sharply carinate, sloping inward from the pinched and elevated keel to the distinct but not conspicuous sutures; space between the suture and the keel irregularly threaded with about 8 spiral lirae overridden by fine, crowded incremental laminae. Aperture crushed in the type but apparently long and narrow, anteriorly produced. Parietal callous heavy, almost—and possibly in a perfect specimen, entirely—sealing the umbilicus, merging into the margin of the outer lip.

Dimensions: Height, 39 millimeters; greatest diameter, 24 millimeters.

Holotype: U. S. National Museum No. 373050.

Type locality: U. S. Geol. Survey Sta. No. 13230, about 12 miles east-north-east of Sayula, Chiapas, Mexico. Eocene.

Amaurellina moragai Stewart[4] from the Tejon of California is more inflated and more ovate in form, and the whorls are less sharply angulated. *Amaurellina moragai lajollaensis* Stewart,[5] from the Domengine horizon is less inflated than the Tejon form, but the whorls are not so sharply keeled as in *A. malinchae*. *Amaurellina malinchae* is known only from the holotype.

Amaurellina cortezi Gardner and Bowles, n. sp.

Figs. 7, 9.

Shell heavy, squat-ovate; spire moderately high for the group, obtusely scalariform. Whorls about 6 in number, regularly increasing in size, obtusely shouldered. Sutures distinct, impressed. Shell smooth excepting for an in-

[4] STEWART, R. B. Op. cit. 334. *pl. 18, fig. 3.*
[5] STEWART, R. B. Op. cit. 335. *pl. 28, fig. 2.*

cremental sculpture which is unusually strong, sharp, and regular. Aperture semilunate; outer lip entire. Inner wall covered by a heavy callous completely sealing the umbilical opening.

Dimensions: Height, 32.5 millimeters; greatest diameter, 27.0 millimeters.

Holotype: U. S. National Museum No. 373048.

Paratypes: U. S. National Museum No. 373049.

Type locality: U. S. Geol. Survey Sta. No. 13230, about 12 miles east-north-east of Sayula, Chiapas, Mexico. Eocene.

There are 18 paratypes of this species in the Chiapas collection. Many of these are broken or poorly preserved and the largest is 46 millimeters high. *Amaurellina clarki* Stewart,[6] so abundant in the Domengine of the Simi Valley, differs from *A. cortezi* in the relatively higher and more turrited spire, the less inflated and more produced body whorl and the less expanded aperture.

VOLUTIDAE

Volutocristata Gardner and Bowles, n. gen.

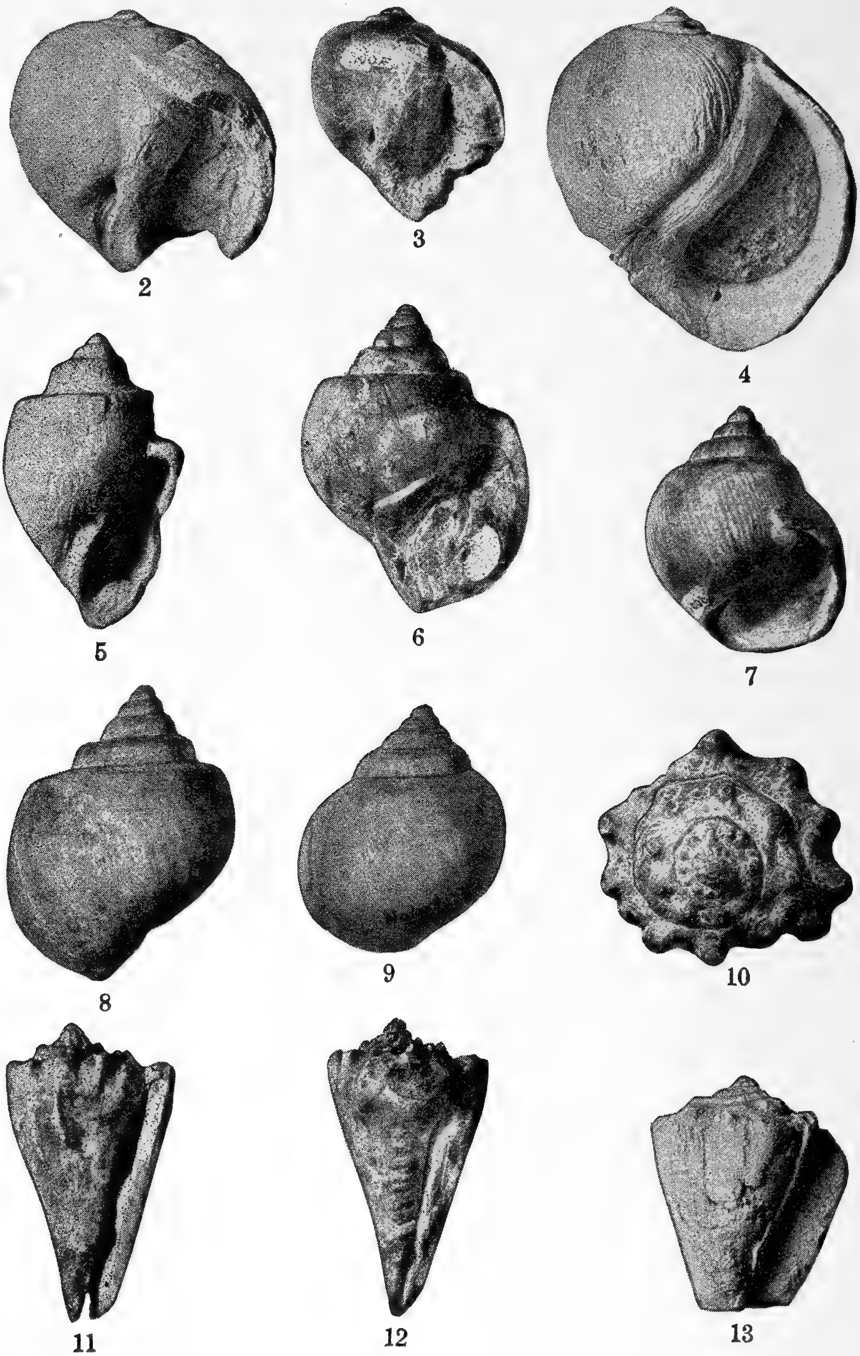
Genotype: *Volutocristata chiapasensis* Gardner and Bowles. Middle Eocene of Chiapas, Mexico.

Shell coniform; spire depressed but the apex a rather prominent boss; nuclear whorls not well preserved, but certainly small and few in number; post nuclear whorls about 5 in the genotype, the later whorls wound close to the tubercled periphery of the preceding volution; body conic, slightly concave laterally; abruptly shouldered; apical surface ornately sculptured; early whorls with 11 to 13 prominent axial ribs which on the later whorls are reduced to erect peripheral tubercles evanescing on the body within the posterior third; incremental striae crowded and rather sharp; axial sculpture overridden by fine, crowded, somewhat irregular lirae; base of body obliquely sulcate, the grooves more closely spaced anteriorly; sutures distinct, undulated by the peripheral nodes of the preceding volution; aperture narrow, elongate with subparallel margins; outer lip entire with a simple, bevelled edge; columellar wall plicate, the anterior fold the strongest and the most oblique, the 4 or 5 behind it less sharply defined and irregular in size and spacing and almost at right angles to the axis of the shell; all of the folds deep-seated and visible only in the broken shell or in moulds; parietal callous heavy, washed backward over the preceding volution in the adult whorls; anterior fasciole narrow, the terminal notch shallow.

This genus has been erected to accommodate two similar and remarkable volutes, *Plejona lajollaensis* Hanna[7] from the Domengine (middle Eocene) of California and *Volutocristata chiapasensis*, the genotype, from the Isthmus of Tehuantepec. They are characterized by the conspicuously coniform outline, depressed spire, crested periphery and the very narrow aperture with sub-parallel margins.

[6] STEWART, R. B. Op. cit. 336. *pl. 26, figs. 8, 9.*

[7] HANNA, M. A. Univ. California Dept. Geology, Bull. **16**: no. 8, p. 320. *pl. 52, figs. 1, 2.* 1927. "*Pejona*" by typographical error.



Figs. 2–13.—For explanation see opposite page.

The genus *Volutoconus* of Crosse[8] though suggesting a coniform shell includes species with a more typically volutoid aperture, rounded shoulders and an oliviform rather than coniform outline.

The form most closely resembling *Volutocristata* pictorially is *Diploconus crassus* Douville[9] from the *Cardita beaumonti* beds of northern India.

The genus *Diploconus* was erected by Douvillé[10] to cover two species, the genotype *D. elegans*, a relatively high-spired form, and *D. crassus*. *Diploconus* was referred to the Fusidae in which Douvillé included *Turbinella*, but in his discussion, he emphasized the characters common to the Strombidae and recognized in *Diploconus* an indicator of a common ancestry for the fusids and strombs. Douvillé's figures suggest that the outer lip in adult *Diploconus* is pulled slightly backward over the preceding whorl as it is in the strombs, but this is not true of the American forms and may not be true of the Indian, for the material figured by Douvillé is mostly in the form of incomplete moulds. The columellar folds of the Indian species seem stronger and more oblique but this difference is probably more apparent than real for the folds of the American species are deep seated and can be adequately observed only in the broken shell. No genetic relationship between the Indian and American faunas can be surely established on the material available, but such a relationship is a possibility of unusual interest as it involves the early migration routes of the Tethyan faunas. The Tethyan, the ancestral Mediterranean, sea was presumably closed on the west by the "Cathaysia" of Grabau, and was thus isolated from the equatorial Pacific, though it may have been open to the Atlantic by way of northern Africa. Forms similar to *Diploconus* are unknown in either the fossil or the Recent Japanese faunas.

Among the American volutes, the closest relationship may perhaps be found with *Volutocorbis* Dall, a group remarkably prolific in the American Eocene. Variants of the genotype, *Volutilithes limopsis* Conrad from the

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Fig. 2–3. *Cernina* (*Eocernina*) *chiapasensis* Gardner and Bowles. 2. Apertural view of holotype, ×1. 3. Apertural view of paratype, ×1. Fig. 4. *C.* (*Eocernina*) species cf. *C. hannabali* (Dickerson) from the Simi Valley,[11] California. Apertural view, ×1. Fig. 5. *Amaurellina malinchae* Gardner and Bowles. Apertural view of holotype, ×1. Fig. 6. *A. clarki* Stewart from the Simi Valley, California. Apertural view, ×1. Fig. 7. *A. cortezi* Gardner and Bowles. Apertural view of holotype, ×1. Fig. 8. *A. clarki* Stewart from the Simi Valley, California. Rear view of individual shown in Figure 5, ×1. Fig. 9. *A. cortezi* Gardner and Bowles. Rear view of individual shown in Figure 6, ×1. Fig. 10–12. *Volutocristata chiapasensis* Gardner and Bowles. 10. Apical view of paratype, ×1. 11. Apertural view of holotype, ×1. 12. Apertural view of holotype broken to expose columellar plications, ×1. Fig. 13. *V. lajollaensis* (Hanna) from the Simi Valley, California. Apertural view, ×1.

[8] CROSSE, H. JOUR. DE CONCHYL., ser. 3, **19**: 306. 1871.

[9] DOUVILLÉ, HENRI. *Les Couches a* Cardita Beaumonti. Geol. Survey of India, Mem., Paleontologia Indica, new ser., **10**: 38, *pl. 7, figs. 8, 9.* 1929.

[10] Idem., p. 136.

[11] All of the specimens from the Simi Valley are from U. S. Geol. Survey Sta. No. 12632, collected by W. P. Woodring on the north side of the Simi Valley, on the east side of Las Llajas Canyon, 6850 feet South 17½° East from Bench Mark 2165, Ventura County, California.

Gulf Eocene, are widespread in the lower Claiborne of Texas and northern Mexico. There are numerous obvious differences between the genera, the most significant, perhaps, being the more regular and stronger plications upon the pillar of *Volutocorbis*, which unlike those of *Volutocristata*, emerge at the aperture. In *Volutocorbis*, however, as in *Volutocristata*, the parietal wash is extended backward upon the preceding whorl in adult individuals, and the two groups are similar in the direction of the growth lines, the grooving upon the base of the body, the characters of the anterior fasciole, and the general sculpture pattern.

Volutocristata chiapasensis Gardner and Bowles, n. sp.

Figs. 10–12

Shell of moderate dimensions and rather heavy, coniform. Spire depressed but the apex a prominent boss. Body elongate-conic, gently tapering and slightly concave, laterally. Nuclear whorls imperfectly preserved and differentiated but certainly small and few in number. Post-nuclear whorls about 5, rapidly increasing in size, conspicuously shouldered. Post-nuclear axial sculpture gradually changing from narrow ribs continuous from suture to suture on the early whorls to prominent peripheral nodes on the later, the number running from 11 to 13 to the whorl; fine spiral striae superposed upon the axials, strongest relatively and most regular upon the early volutions; base of body obliquely sulcate, the grooves more closely spaced anteriorly; sutures incised, undulated by the axials of the preceding whorl. Aperture narrow, the margins sub-parallel. Outer lip simple, the edge bevelled. Pillar wall plicate, the folds deep seated and not emergent at the aperture; anterior fold the strongest and the most oblique; the 4 or 5 folds behind it irregular and approximately at right angles to the axis of the shell. Parietal wash moderately heavy, transgressing the shoulder on the last two volutions and partially overriding the peripheral nodes. Anterior fasciole narrow and inconspicuous; the terminal notch very shallow.

Dimensions: Height, 39.5 millimeters; greatest diameter, 23.5 millimeters.

Holotype: U. S. National Museum No. 373044.

Paratype: U. S. National Museum No. 373045.

Type locality: U. S. Geol Survey Sta. No. 13230.

Volutocristata chiapasensis is represented by the holotype and a broken paratype consisting of the apical portion only. The maximum diameter of the paratype is 34 millimeters and the axial nodes total 55 or 56. *Volutocristata lajollaensis* (Hanna) from the Domengine of southern California is the only known American species remotely resembling specifically our Mexican form. It differs in the relatively broader body whorl; the less sharply angulated keel; the less prominently elevated but more acute peripheral nodes; the more posterior suture which follows closely the periphery of the later whorls rather than falling a little in front of the periphery as it does in *V. chiapasensis;* and the sharper, more uniform and more regularly spaced columellar plications.

PALEONTOLOGY.—*New Carboniferous invertebrates*—IV.[1]

GEORGE H. GIRTY, U. S. Geological Survey.

This paper contains descriptions of one brachiopod from western Texas, five gastropods from Colorado, and three gastropods from Arkansas.

Cryptacanthia? robusta n. sp.

Figs. 1–7.

Shell rather large for the genus, subpentagonal in outline, highly inequivalve with reversed curvature, the pedicle valve having a pronounced fold and the brachial valve a pronounced sinus.

The pedicle valve is widest at the mid-length or just above and somewhat emarginate in front with an outline more or less conspicuously pentagonal. Longitudinally, this valve is gently arched toward the anterior end, but shows a rapidly increasing curvature toward the beak which rather strikingly overhangs the brachial valve. Transversely, the median part is more or less planate at the anterior end, the flattened zone contracting posteriorly to form a narrowly rounded ridge which terminates in the small incurved beak. From this flattened median part the lateral slopes descend steeply and to an uncommon length, causing the valve to be correspondingly convex. The lateral slopes are flattened or even somewhat concave and they seem to flare slightly in the region of the cardinal angles. On some specimens the descent from the fold is so abrupt close to the anterior margin as to produce two short but pronounced grooves and to give that structure, which would otherwise be undefined, distinct boundaries and a quadrate shape. The beak in my specimens is imperfect but it appears to have been truncated by a round foramen without any collar formed by the introverted shell margin adjacent.

The brachial valve is subquadrate in outline and moderately convex. It is strongly and more or less abruptly deflected at the sides and across the front, leaving a median area (for half or two-thirds of the length) which is but slightly arched. The sinus, which makes its appearance back of the middle of the valve, is in the beginning a narrow groove, but it widens rapidly and somewhat abruptly, the bottom, at the same time, becoming more rounded and at the anterior margin almost planate. There, the part included in the sinus projects as a linguiform extension which is folded downward at a strong angle, one, however, appreciably greater than 90 degrees. The parts on either side of the sinus are also deflected downward, though less strongly than the sinus itself, with an almost truncating effect. As an extreme expression this valve is planate over the posterior part and abruptly flexed along three sides, so that the planate area has a certain definition. The lateral and anterior folds in conjunction with the broad deep sinus, cause this area to terminate on either side in prominences almost like little mounds.

Of internal structures little is known except that the pedicle valve is provided with dental plates and the brachial valve with a strong median septum. The shell substance is finely punctate.

[1] For the previous paper in this series see this JOURNAL **21**: 390–397. 1921. Published by permission of the Director of the U. S. Geological Survey. Received Sept. 19, 1933.

C. robusta so closely resembles *Cryptacanthia compacta* as to raise a doubt whether it is more than a very robust form of that species, yet the facts regarding both are so incompletely known and in certain respects so at variance as to suggest that they belong to distinct genera. The possibility that they belong to different genera is opposed by their close external similarity. Such a resemblance would mean little or nothing between many species but in this instance it is significant because the configuration which these two possess in common is highly exceptional and distinctive. On the other hand, the original description of *C. compacta* does not mention the dental plates and median septum which are shown by the present species, and it does give the character of the brachidium whose characters in the present species have not been determined.

C. compacta is one of the rarest of Carboniferous brachiopods and no first hand description of it has been published since 1868 until very recently. Dunbar and Condra, however, redescribe the genus with some additional characters among which, significant in the present connection, are the presence of dental lamellae in the pedicle valve (a character which could be predicated with reasonable assurance as it is found in all or nearly all Carboniferous Terebratuloids) and the absence of a median septum in the brachial valve. I hesitate to challenge the character last mentioned and at the same time cannot accept it unconditionally for the following reasons. I have examined specimens of *C. compacta*, especially one from the Murphysboro quadrangle (station 6129) in which a median septum certainly appears to be present, though it may not have the form of a thin high plate. Furthermore, the specimen which supplied the structural characters described by Dunbar and Condra and which in their sections seem to afford conclusive evidence that a septum was absent, came from New Mexico and is strikingly unlike the authentic specimen shown by the original publication. Their figures (p. 309) represent a shell that is much more elongate, that is ovate in outline instead of pentagonal, and that has a moderately convex instead of a nearly flat brachial valve. On these grounds one might infer that their specimen did not belong to *C. compacta* and might not belong to *Cryptacanthia* at all. These differences are less marked, however, if the figures on p. 309 are compared with figures on plate 37 representing specimens from Kansas and Illinois. The fact that a median septum was not mentioned in the original description cannot be taken as corroborating the observations of Dunbar and Condra for the original description also failed to mention the much more obvious dental lamellae.

If *Cryptacanthia* did indeed lack a median septum in the brachial valve, the present species can hardly remain in the same genus as *C. compacta*. In the presence of this septum it suggests the genus *Heterelasma*, not to mention *Girtyella* and others, but in configuration it is the reverse of *Heterelasma* whose characters in this category are singularly misrepresented in the American Zittel. In that usually accurate work the genus is summarized as

comprising "smooth Dielasmids with a ventral fold and a dorsal sinus." In point of fact, the transverse curvature of the ventral valve in *Heterelasma* is concave, in other words, it has a sinus not a fold, and that of the brachial valve is convex, but the convex curvature is reversed in the anterior part which is indented by a more or less conspicuous sinus. The present species which really has a fold in the ventral valve and a sinus in the dorsal valve might well belong in *Heterelasma* as the genus is represented in Zittel, but not as it is in fact. If it does not belong in *Heterelasma* by reason of the reversed curvature of the valves, or in *Cryptacanthia* by reason of the median septum in the brachial valve, its generic affinities are hard to discover. In configuration it recalls the Jurassic genus *Glossothyris* and in default of a suitable generic locus the term *Glossothyropsis* might be used for it.

In its specific relations as already pointed out *C. robusta* greatly resembles *Cryptacanthia compacta* and when the doubtful points are cleared up, it may belong in the same genus. As a summary of the differences at present known, aside from those of generic significance, *C. robusta* is much larger; the lateral outlines appear to contract more gradually forward so that the anterior outline is broader than it is in *C. compacta;* the two valves appear to be much less unequal in convexity, the pedicle valve being somewhat lower and not so angular along the median line, and the brachial valve not quite so planate; and the fold and sinus are higher and conspicuously quadrate in outline. These differences can not be wholly vouched for, as the original description and figures of *C. compacta* are inadequate in several respects, and as specimens are rare. I have been able to examine only 10 or 12 specimens, all of them small and more or less broken. Their imperfections tend to vitiate the identification, but it is probable that they belong to *C. compacta.* The fact that *C. robusta* occurs in a widely unlike fauna of much later geologic age adds significance to the differences already known and gives promise of others when our knowledge is more complete.

C. robusta occurs associated with *Pugnax bisulcata,* which it resembles so closely in configuration that on a hasty examination the two species might readily be confused; the resemblance, of course, is only superficial and scarcely that, inasmuch as it exists only through a reversal of the valves, the pedicle in this species resembling the brachial valve in that and vice versa.

Delaware Mountain formation (Permian); True Canyon, 7 miles northwest of 7-Heart Gap, Culberson County, Texas (station 6452).

Pleurotomaria worthenioides n. sp.

Figs. 8, 9.

Shell small, conical, turreted, consisting of 5 or 6 volutions. Apical angle less than a right angle but varying with different specimens. Aperture rhombic. In the final volution the peripheral region is occupied by two large rounded carinae which inclose between them a flattened and much depressed

zone containing the slitband. The lower of the two carinae is almost basal and is slightly smaller and less prominent than the upper. The surface between the suture and the upper carina is broad, strongly oblique, and nearly flat though it is slightly tumid near the suture and more or less spreading as it joins the carina. The lower surface is gently convex and nearly horizontal except that near the axis it bends strongly upwards. The whorls embrace up to the lower carina which is concealed in some specimens and partly exposed in others. The upper carina on the other hand forms a conspicuous projection and lends the shell its turreted appearance. The axis seems to be imperforate.

The lateral surface is marked by 6 or 7 fine, sharp, revolving lirae which diminish in size from above downwards and are separated by interspaces wider than the lirae themselves. About 4 similar lirae, but finer and more crowded, occur on the upper carina and two or three others like them on the lower carina. The lower surface is marked by about 10 revolving lirae which are coarser and stronger than those of the lateral surface, and stand rather more than their own diameter apart. The interspaces gradually diminish toward the axis and the lirae decrease in size and strength in the same direction. The sculpture also comprises fine, regular lamellose transverse lirae. On the lateral surface they decrease in size individually from above downward and are perhaps a little more delicate than the revolving lirae and possibly a little more closely arranged. They form with the revolving lirae a regular cancellated sculpture marked at the intersections by minute but conspicuous nodes. The transverse lirae are well developed upon the upper carina, cancellating the revolving lirae that occur there, and they reappear on the lower carina. Over the basal surface they are a minor feature. If well developed or well preserved they are sharp and clear, but much more delicate and much more closely arranged than the revolving lirae which they cross as crenulations rather than as nodes. The slitband occupies nearly the whole of the depression between the two carinae and is defined by lamellose lines partway up its sides. The slitband is divided longitudinally by a slender revolving lira set with minute, closely arranged, uniform nodes, whereas each of the divisions is subdivided by a lira more or less inferior in size. In the slitband the transverse lirae appear as delicate close-set lunettes which on many specimens are somewhat difficult to make out and are chiefly apparent by reason of the nodes that they produce in crossing the median lira.

On the lateral surface the growth lines have a strong backward trend from the suture and a slight convexity toward the aperture. In crossing the slitband of course they are conspicuously arched with the convex side facing backward. On the lower surface their general direction is about transverse but they retreat into a broad shallow concave arc just below the lower carina and make a short shallow convex arc in the axial region.

This species is not exactly rare; about 25 specimens, large and small, have been examined, but only a few of the large ones are well preserved, whereas the small ones are identified with less accuracy. Some of the variation observed is probably due to imperfect preservation. That the revolving lirae vary somewhat in number and arrangement scarcely need be specified. In some specimens revolving lirae seem to be obsolete on the carinae, the transverse lirae alone being distinguishable. The carinae then appear flat on top instead of rounded. The delicate though sharp lunettes in the slitband are

more often invisible than seen, and the transverse lines of the lower surface may be sought for in vain. Probably they are fully developed, but are subdued to the strength of growth lines, or obscured by abrasion. On a few small specimens from Woolsey, Ark. (station 2849) the upper carina is uncommonly thin and prominent.

Brentwood limestone member of the Bloyd shale (early Pennsylvanian); SW$\frac{1}{4}$ sec. 27, T13N, R32W, Winslow quadrangle, Arkansas (station 3733).

Euconospira hermosana n. sp.
Figs. 10–12.

Shell small, conical, composed of about seven gradually enlarging volutions. The spire comprises half, or a little more than half, of the entire height, and the height is slightly greater than the width of the last volution.

Final volution somewhat rhombic in section and strongly carinated around the periphery which is at the mid height or somewhat below. The lateral surface, which is slightly concave, descends steeply from the suture. The lower surface, which is gently convex, descends from the periphery inward, but in the axial region it rather sharply assumes an upward direction. The peripheral zone is occupied and truncated by the slitband, which is rather narrow and depressed between two thin strongly projecting lamellae. Below the carina, that is, on the lower surface but in the peripheral part, there is a narrow groove which in width is about equal to the slitband, and which is separated from the slitband by the lower of the two bounding lamellae; below this again and of about the same width there is a narrow, rounded ridge. The volutions embrace to this spiral ridge, so that the carina forms a somewhat conspicuous projection winding around the shell, but losing its elevation as it approaches the apex.

The surface is crossed by numerous slender, sharply elevated transverse lirae distinctly narrower than the striae between them, little difference in sculpture being observable between the lateral and basal parts. On the upper surface these lines are at the same time convex (toward the aperture) and oblique, with a rather strong backward swing. On the lower surface they are sinuous but on the whole generally transverse in direction. Starting at the slitband they have for a short distance a forward direction but turn backward as they cross the revolving ridge on the basal surface. Thence, they make a broad shallow reentrant curve, followed by a broad shallow convex curve, the change in direction occurring about midway on the lower surface. As these lines necessarily converge toward the axis, many that begin at the carina die out or become confluent to form lirae of larger size; the others apparently become somewhat strengthened so that the peripheral half of the lower surface is more finely striated than the axial half. In the slitband the transverse lines make distinct lunettes, the markings here being similar to those elsewhere on the shell but considerably finer. Traces of extremely fine spiral lines have been observed in the slitband. They are interrupted by the lunettes or confined to the spaces between them. Some 5 or 6 of the transverse lirae of the upper surface are spanned by 1 mm., the measurement being made at right angles to their oblique direction. On the lower surface the liration is somewhat finer near the carina but it becomes as coarse if not coarser toward the axis through confluence or fasciculation of the lirae.

In typical *Euconospira* the surface is crossed by spiral as well as trans-

verse lines, producing a cancellated ornamentation. *Euconospira Hermosana* has no such spiral lines, and this fact although it is not regarded as debaring it from *Euconospira*, at once distinguishes it from a number of species there referred. Several species of *Euconospira*, it is true, have only traces of spiral lines (such as the very robust *E. taggarti*), or have spiral lines only on the under surface. *Pleurotomaria coniformis*, *P. conulus*, and *P.* (*Bembexia*) *elegantula*, which possibly should be referred under *Euconospira*, have, like the present species, only transverse lirae, but they are sharply distinguished from it in other ways.

McCoy formation of Roth (Pennsylvanian); McCoy, Colorado.

Pleurotomaria rockymontana n. sp.
Figs. 13–16.

Shell of moderate size, elongate, conical, composed of 10 or more gradually enlarging volutions. Spire about twice the height of the final volution and distinctly but not strongly turreted.

Final volution irregularly rhombic in section with the basal surface gently convex and almost horizontal, with the lateral surface strongly oblique, and with the carinated periphery sharply rounded or subtruncate. The lateral surface is slightly sinuate, somewhat protuberant in the upper part and somewhat flaring in the lower. The peripheral angle, which is rounded as just described, is the locus of 2 revolving ridges or carinae of which the higher is slightly the more prominent. Adjacent to the lower carina, but on the underside of the volution is a third ridge distinctly inferior in size and prominence. It is separated from the lower carina by a narrow groove, somewhat narrower and shallower than the groove inclosed between the two peripheral carinae.

The lateral surface of the final volution is crossed by small spiral and transverse lines which form a regular and fine cancellation marked with little nodes where the lines intersect. The spiral lines are slender and spaced at about their own width or somewhat more. They are subequal but gradually diminish in size and prominence from above downward. About 8 can be counted on one specimen; one or two more on others. The transverse lines are about the same in size and spacing as the spiral ones on some specimens but on most they are the dominant feature being conspicuously stronger and more widely spaced. They are in the upper part almost straight and almost direct but bend backward more or less strongly as they approach the upper carina so that they have, in that degree, a general backward trend.

The markings of the peripheral zone vary much in detail on different specimens, probably due to the minute character of the units and to their imperfect and unequal preservation. Where most clearly distinguishable the slitband is a narrow flat ribbon deeply depressed between the two peripheral carinae. It appears to be defined by delicate lirae on the sides of the carinae and it is marked by very fine, closely arranged lunettes. The occurrence of the lirae is such that the carinae sometimes appear to be surmounted by two revolving lirae. This is especially true of the lower carina because it is somewhat smaller and less prominent than the upper, and the lira on its inner side is more on a parity with it. In one specimen the slitband is not distinguishable as such, but instead the groove between the carinae appears to be occupied by several fine spiral lines. These features are not shown clearly or

in detail, however. The transverse lirae apparently do not pass the upper carina, which is not crenulated, and when they reappear in the slitband they are very much finer and more closely arranged. Nor have they been detected on the lower carina, but in the groove just below it the transverse lines reappear with a sharp expression and with a marked forward slant from above. Traces of fine spiral lines are also shown here by some specimens, and probably they are a constant feature. The sculpture of the basal surface from the lower carina to the axis, is not well shown. It seems to be cancellated like the lateral surface, but more finely. The revolving lirae are more slender, more closely arranged and consequently more numerous, and the transverse lines are even finer. They are greatly inferior to the transverse lines of the lateral surface so that whereas there the transverse lines are the dominant feature, the spiral lines have here the dominant part. The volutions embrace so as partly to conceal the lowest of the three revolving ridges that occupy the peripheral zone exposing, however, its crest together with the groove above it and the two peripheral carinae with their included groove. These projections break the regular slope of the spire and give the conical shell its somewhat turreted shape.

This species appears to resemble *P. adamsi* in a general way. Worthen's description, however, is not clear, in fact seems to be contradictory regarding certain details. In point of sculpture it mentions only spiral lines on the two carinae which inclose the slitband. One part, at least, of the final volution is said to be smooth, apparently the basal surface ("smooth below the spiral band"); this is not true of any part of *P. rockymontana. P. adamsi* also has a wider spiral angle. *P. giffordi* is on the whole somewhat more similar but it has fewer spiral lines on the lateral surface and apparently no transverse lines at all; there are other differences as well, such as showing a greater depth of shell below the slitband in the final volution and above the suture in the higher ones and lacking a third ridge below the two carinae that inclose the slitband. *P. subdecussata* and *P. rockymontana* are also comparable in a number of details, more in sculpture than in configuration, as *P. subdecussata* has a much lower spire. *P. subdecussata* resembles the present species and differs from the two previously mentioned, in having the lateral surface finely cancellated by numerous revolving and transverse lines, but like the foregoing it appears to lack the additional carina below the two on the periphery.

McCoy formation of Roth (Pennsylvanian); McCoy, Colorado (station 6714).

Orestes? reticulatus n. sp.
Figs. 17–19.

Shell rather small, subconical, composed of about seven volutions. Width and height nearly equal.

Final volution rhombic in section with the peripheral line well-nigh basal. The lateral surface juts out at the suture to form a narrow shelf-like projection which, though slightly inclined is almost horizontal. From this tablet, which it meets in a pronounced angle, the main part of the lateral surface, sloping steeply, drops down to the periphery without material interruption.

The peripheral angle, which is about 60 degrees, is somewhat truncated or sharply rounded. The lower surface is almost planate and almost horizontal. It descends appreciably from the peripheral angle and in the axial region makes a sub-angular turn, bending upward with a slight obliquity. The axis is solid and the lip slightly reflexed to form a false umbilicus. The rather broad slit band occurs just above the periphery and is sharply defined by two rather thick prominent lirae. Just below the lower of these lirae but still above the peripheral line the surface retreats into a rather narrow deep rounded groove, and this is followed by the periphery itself, consisting of a narrow rounded ridge which in width is about equal to the groove above and in prominence scarcely exceeds the guarding lirae of the slitband. Thus the peripheral region is marked by three slender ridges or carinae separated by two grooves. The lower carina is decidedly thicker than the two above that inclose the slitband, and the slitband or upper groove is much broader than the lower. The volutions embrace up to and including the lowest ridge, so that the groove above and the slitband are exposed. This gives the shell as a whole an obscurely turreted appearance. As the whorls are followed backward up the spire, they lose their angulated shape and become more regularly rounded.

The sculpture in general terms consists of a rather coarse reticulation made by sharply raised revolving lirae crossed by transverse lirae of about the same size and spacing. Small but rather conspicuous nodes emphasize the points where the lirae intersect. Reckoning the sharp edge of the shelf-like projection below the suture as a lira, from 6 to 8 revolving lirae occupy the lateral surface and an additional lira not uncommonly occurs upon the sub-sutural tablature. The lirae are as a rule rather regular in size and spacing, but they may vary greatly, and in both items they show a general diminution downward toward the slitband. The two slender lirae that inclose the slitband are not distinguished from the lirae above except that they are a little more prominent and are not affected by the transverse lirae. They are smooth or in places finely notched or crenulated. Two rather small spiral lines close together form the peripheral curve or carina (wherefore its rounded instead of angulated shape) and from 10 to 13 others are developed on the lower surface. This part of the shell is somewhat more finely marked than the lateral surface, the lirae being more slender and the intervals narrower, though on both surfaces the intervals are decidedly wider than the lirae. The slitband generally appears to be without spiral lines and to be marked only by the usual lunettes, but in one specimen the slitband is divided by a single delicate raised line, and in several it shows traces of numerous exceedingly minute lines which seem to be interrupted by the much stronger lunettes and confined to the intervals between them.

The transverse lirae on the lateral surface are about like the spiral lirae, rather strong and coarse, and between the two, the lateral surface is divided into rather large rhombic areas. The transverse lirae come to an end at the raised line that forms the upper boundary of the slitband. They are not continuous with the lunettes in the slitband which are in fact much more numerous and more closely arranged. Nor do they account for the crenulations on the lira that bounds the slitband above (when these can be seen at all) for the crenulations are even finer than the lunettes. On the lower surface the transverse lirae are generally finer, more subdued and more closely arranged than they are on the lateral surface. They show considerable irregularity on the same specimen and great variation between different speci-

mens. Compared with the revolving lirae which they intersect, they are less conspicuous; they are also more closely arranged so that the parallelograms which they help to inclose are much longer than they are wide. Here on the lower surface they are associated with growth lines to which they are similar in kind but superior in strength.

In direction, the transverse lirae spread straight out from the suture, but take on a slight backward trend at the angular margin of the tablature that surrounds it, and at the same time they become arched (convex side toward the aperture), so that upon reaching the upper boundary of the slit band their backward direction is very pronounced. The transverse markings on the slit band itself make the usual concave arch. On the lower surface the transverse lines have a gentle backward trend from the periphery and are gently sinuous in shape. Close under the slit band they have a forward direction, but, making a turn on the periphery they first describe a concave curve and then when half-way across, a convex curve. These curves, which are expressed with reference to the outer lip, are very broad and shallow.

In some respects *Orestes*? *reticulatus* resembles the species which Keyes thought might be the one which Meek and Worthen thought might be Shumard's *Pleurotomaria brazoensis*. Shumard's species, as I interpret it on specimens from Texas, is a characteristic member of the genus *Orestes*, and is very different from Meek and Worthen's shell. The latter must be called *Pleurotomaria intertexta*, a reversional name which those authors suggested in case it proved to be distinct from *P. brazoensis*. *P. brazoensis* of Keyes, on the other hand, seems to be a quite different species from the *P. brazoensis* of Meek and Worthen (or *Pleurotomaria intertexta*) and even more different from typical *P. brazoensis*. Though not identical with *Orestes*? *reticulatus*, it is much like it in general appearance. Its shape, however, is more turreted and less conical; its slit band is broader, is divided by a median line, and is peripheral in position instead of being above the periphery with a groove below it. The carinae on either side of the slit band are not simple raised lines or ridges—they are compound, the upper being formed by two raised lines and the lower by two or three. Furthermore, the transverse lines are of two orders and so disposed that from three to six of microscopic size intervene between two of the larger ones. Something like this can be observed on the lower surface of *O. reticulatus* though the intermediate lines are subdued and incremental in character, but on the lateral surface, growth lines, if present at all, are only just discernible. Thus, the obvious resemblance between *O.*? *reticulatus* and the *Pleurotomaria brazoensis* of Keyes is of a general character, and critical comparison discloses many differences in detail.

McCoy formation of Roth (Pennsylvanian); McCoy, Colorado (station 6714).

Orestes? quadrilineatus n. sp.
Figs. 20–22.

In its general character and also in many details this species is closely allied to *Orestes*? *reticulatus*. It is, however, more depressed and in shape more

or less hemispherical whereas the other is more or less conical. This difference is partly due to the shape of the constituent volutions which are more rounded, and partly to their adjustment to one another. The more rounded shape of the volutions manifests itself in several details. The lateral surface is more arched and at the same time less oblique; the lower surface likewise is more arched, dropping farther below the peripheral zone. The peripheral zone is much less angular, for whereas in *O.? reticulatus* the part below the slitband projects beyond the part above, so as to form a sharply rounded peripheral angle, in this species the two parts project about equally, so that the slitband appears to occur rather upon a broadly rounded peripheral zone than above a narrowly rounded one.

The two species differ perhaps more in configuration than they do in sculpture, but the sculpture too, though the same in general character, is different in certain details. The spiral ornamentation in *O.? quadrilineatus* consists of fewer and sometimes thicker lines more widely spaced and the transverse ornamentation also, though varying greatly in scale, is on the whole somewhat coarser. The lateral surface is commonly marked by 4 strong, sub-angular, revolving costae separated by rounded grooves of much larger size. This enumeration does not include the raised line that bounds the slitband on its upper side, but it does include the ridge that marks the outer limit of the tablature below the suture. These four revolving costae can not be said to have any constant or characteristic arrangement for they vary in spacing from specimen to specimen, but rather commonly the upper one stands some distance from the suture and the intervening surface may, by reason of the rounded shape of the volution, incline slightly downward toward the suture instead of declining slightly away from it. On the other hand the side of the surface may arch inward regularly to the suture without forming any distinct tablature. The lowest of the 4 costae, as a rule, occurs rather close to the slitband, but is separated by a rather broad interval from the one above. The one above (or the third from the suture) may be somewhat smaller than the rest or it may be entirely undeveloped. In that event there would be 3 instead of 4 of these revolving costae. All four, however, may be essentially equal in size and spacing. The transverse lirae instead of tracing a regular backward curve from the suture as in *O.? reticulatus*, reach the same end by an angular change of direction where they cross the spiral ridges, the points of intersection being marked by nodes which though actually small are sometimes prominent and striking. Thus, the shelf-like jutting of the shell below the suture is apt to be conspicuously and handsomely marked by strong lines which spread out from the suture, form pronounced nodes on the revolving ridge that forms its outer boundary, and pass backward by successive angles to the slitband. This shelf-like projection, crossed by transverse lines and bordered by a row of nodes, is in many specimens a conspicuous feature.

O. quadrilineatus is closely related to *O. reticulatus;* the fact of relationship is clear and the degree is not. Taken together a rather large number of specimens have been examined but many of these specimens have been crushed, some completely flattened, so that their original shape at best can only be surmised; to that extent it is impossible to determine how far the differences in configuration and the differences in sculpture above described are parallel developments, especially as the sculpture also is defaced in some specimens.

Judged by such specimens as retain both features more or less faithfully the two species appear to intergrade. Some specimens represent a more or less intermediate condition between the low hemispherical shape distinctive of *O. quadrilineatus* and the high conical shape distinctive of *O. reticulatus.* Again some specimens that in configuration appear to belong with the one species have a sculpture tending to ally them with the other. In fact the sculpture is not at all constant, varying if only in minutiae from specimen to specimen. Yet we have the counter-vailing fact that the low hemispherical shells do generally differ in sculpture as well as in shape from the high conical ones and that the extremes are conspicuously unlike.

McCoy formation of Roth (Pennsylvanian); McCoy, Colorado (station 6714).

Pleurotomaria aspera n. sp.
Figs. 23–25.

Shell small, conical, composed of 6 or 7 regularly enlarging volutions. Spiral angle about 60°. Spire with rather flat sides interrupted by the suture which is indented though not deeply.

Final volution trapezoidal in section with the peripheral line almost basal. The lateral surface is nearly planate, descending steeply from the suture and passing below into the peripheral angle which is narrowly rounded. The basal surface, though nearly flat and nearly horizontal descends slightly from the periphery and bends upward rather abruptly in the axial region. The slit-band is situated on the peripheral angle and the volutions embrace to or almost to its lower boundary. The axis is solid, but the lip appears to be slightly reflexed forming a small indentation.

The sculpture, as is usual in these shells, consists of spiral and transverse lirae but as the lirae are uncommonly strong and coarse for so small a species they give the surface a conspicuously rough appearance. The side of the last volution is marked by 5 or 6 primary lirae which are more or less equal in size and separated by somewhat wider interspaces. The interspaces, like the lirae, vary somewhat in width and one or more of them may be occupied by a secondary lira; thus the sculpture presents great variety in detail. The transverse lirae are not quite so strong as the revolving lirae and they are not quite so far apart. The intersections of these decussating lines are marked by exceptionally large nodes. The nodes are somewhat elongated in line with the transverse lirae which are thin and depressed in the intervals between them. Thus the nodes have a strict linear arrangement in a transverse as well as in a spiral direction. This double alignment is not well shown in the illustrations in which the transverse arrangement is hardly distinguishable while the spiral arrangement is conspicuous. The transverse lirae at the outset are about perpendicular to the suture but in a short distance they bend rather abruptly backward with a gently convex course. The slitband is broad. It is divided by a median lira which is generally stout and strongly nodose, and it is defined above and below by raised lines which are slender and obscurely nodose. If the median lira is large and prominent, as it is in many specimens, it tends to give the periphery an angulated shape. On the other hand, because the median lira is small or for some other reason, the periphery may be strongly rounded instead of angular. As the lirae that bound the slitband resemble the secondary lirae of the lateral surface and

the median lira resembles the primary lirae the slitband is not as well differentiated as it is in many species, being recognizable chiefly by the deflection of the transverse lirae into lunettes, which, as they produce stout nodes upon the median lirae, to that extent disguise instead of distinguish it. The lunettes are strong and rather widely spaced—not quite so widely spaced as the transverse lirae on the lateral surface. On a few specimens the lunettes for some distance near the aperture are feebly developed—scarcely more than growth lines—and in crossing the median lira they produce scarcely more than crenulations. Farther back on the same volution, however, they are strong and nodose.

The markings of the lower surface do not differ materially from those of the lateral surface. The revolving lirae are generally a little more slender and more widely spaced and they are also more regular in size and in arrangement. They are somewhat more numerous (being 8 or 9 in number) but at the same time they cover a wider surface. In comparison with the lateral surface the transverse lirae are decidedly more subdued and more closely arranged, and they are more distinctly subordinate to the associated spiral lirae. The enlargements formed at the intersections are but small, sometimes scarcely appreciable except in the axial region where some of the spiral lirae (rarely more than 2 or 3) are strongly and conspicuously nodose. In direction the transverse lirae have a somewhat backward direction and a slightly sinuous course making close to the slitband a short and gentle convex curve, then a broad and gentle concave curve, and near the axis a second convex curve.

In the earliest volutions on which the sculpture has been observed, it appears to consist entirely of very fine spiral lirae—this refers, of course, to the region above the slitband which is the only part not concealed. Somewhat later transverse lirae become visible though at first they are much subordinate to the spiral ones; still later by a relative increase in strength they become nearly but not quite equal to them.

There are few species in our Carboniferous literature with which *P. aspera* can profitably be compared, those whose sculpture is somewhat similar being mostly much more depressed-conical in shape. *P. granulistriata*, however, is very similar in both shape and sculpture, so much so that selected specimens, though no two have been observed that were even essentially the same in character, might yet be classed as of the same species. The sculpture of *P. granulistriata*, however, is on the whole coarser than that of *P. aspera*, the nodes at the intersections of the decussating lirae are more rounded and prominent and the transverse lirae are less pronounced.

McCoy formation of Roth (Pennsylvanian); McCoy, Colorado (station 6714).

Pleurotomaria woolseyana, n. sp.

Figs. 26, 27.

Shell of medium size, subconical or subovate, somewhat turreted. Volutions about five in number. Spire moderately high with depressed sutures. Aperture subelliptical or slightly rhombic. Axis solid.

The external surface of the final volution is sharply differentiated into three zones—lateral, peripheral, and basal. The narrow peripheral zone

which contains the slitband occurs well below the mid-height. It is approximately parallel to the axis and is either gently concave, when it is defined by slender raised lines, or flattened, when it is defined by distinct angles. The broad lateral surface is moderately convex and declines more or less strongly from the suture. The broad lower surface is almost planate. It has a gentle downward obliquity from the periphery but is strongly upturned in the axial region and also, in some specimens more than in others, near the periphery.

The sculpture comprises spiral and transverse lirae. The spiral lirae occur on both the lateral and the basal surface; the transverse lirae only on the lateral surface. On the lateral surface the spiral lirae are rather strong and closely arranged; they are developed to the number of 10 or 12 and are commonly subequal, though they may irregularly alternate in size. The transverse lirae are apt to be somewhat weaker than the revolving lirae and somewhat finer and more closely arranged. The spiral series shows a gradual increase in scale from the suture to the periphery; the transverse series likewise shows a gradual increase in scale from above downward but also a diminution in strength. The points of intersection of these two series are reinforced as small but pronounced nodes which are distinctly aligned in spiral and transverse rows. Because of the weakening of the transverse lirae in their downward course, the transverse alignment is conspicuous over the upper part of the volution while the spiral alignment alone is distinct in the lowest rows—2 or 3 in number. Sometimes the lirae themselves are inconspicuous but the nodes which they form remain undiminished in strength and in the regularity of their alignment.

The lower surface is marked by revolving lirae, about 12 in number. These lirae contrast sharply with those of the lateral surface in being smooth instead of nodose; as a rule they are also somewhat stronger and more widely spaced. They become more slender and more closely arranged toward the axis. Very fine regular incremental lines are sometimes present and correspondingly fine crenulations are then formed on the revolving lirae; however, even these are rarely to be observed.

The markings of the peripheral zone are delicate and commonly obscure, and they appear to vary from specimen to specimen. The arrangement most often found consists of 3 or 4 equal, closely spaced, revolving lirae without appreciable cross-markings. On some specimens a line having the median position is larger than the rest, and on some only a single line, corresponding to this one, can be made out. The median lira, whether alone or accompanied by others, may be periodically enlarged into minute, beadlike nodes; for any other manifestation of transverse lines, however, one looks almost in vain. There is, however, convincing evidence, both from analogy and occasional observations, that the peripheral zone with its specialized sculpture is the site of the slitband.

The volutions embrace up to the lower border of the slitband, and as the volutions are more or less convex while the band is vertical in direction besides being more or less concave, the suture is correspondingly indented and the spire correspondingly turreted.

In the figured specimen the nodes above the slitband appear to be arranged in spiral lines only, especially the two lowest. Over the upper part of the volution the dual alignment is conspicuous. In fact, certain lights bring out a reversed alignment across the surface. The normal transverse alignment (from the suture downward and to the right) is not adequately shown

by the figure which also is on too small a scale to show the minute nodes on the median lira of the slitband.

P. woolseyana is related, though somewhat distantly, to *P. granulistriata.* It is much larger, the largest of my specimens being 11 millimeters in height and 9.5 millimeters in diameter. Meek and Worthen's species is only about half as large and it also seems to be more constant in its slender conical form. The surface markings of both are the same in general plan, but those of *P. woolseyana* are finer, especially in relation to the size of the shell, and more subdued; 10 to 12 revolving lirae occur on the upper surface as against 3 or 4 in *P. granulistriata,* the lirae on the under side being also more numerous. The lirae of the lower surface are in this species a little larger and more widely spaced than those on the upper, which is just the reverse of the condition described by Meek and Worthen. Furthermore, the slitband in *P. granulistriata* is marked by sharply defined lunettes and is occupied in large part by a single revolving lira that is strongly and somewhat coarsely nodose.

P. woolseyana is much more closely related to *P. millegranosa* besides occurring in the same fauna. The most pronounced difference perhaps is that the slitband in *P. millegranosa* regularly carries a single revolving line that is strongly nodose, whereas the slitband in *P. woolseyana* has from 1 to 4 revolving lines that are not nodose or are but partly so; this difference, however, is but a general tendency, not invariably pronounced. Again, in *P. millegranosa* the sculpture of the lateral surface is coarser, the nodes are larger, and their arrangement in spiral lines, more conspicuous—or at least an arrangement in transverse lines is less so.

Brentwood limestone member of the Bloyd shale (early Pennsylvanian); bank of stream about 1¼ miles south of Woolsey, Arkansas. Winslow quadrangle (station 2849).

Pleurotomaria millegranosa n. sp.

Figs. 28, 29.

Shell small, subconical, composed of 5 or 6 volutions. Height and width about equal. Suture depressed.

Final volution somewhat rhomboidal in section with the periphery well below the middle. The lateral surface is strongly oblique and gently convex, slightly prominent close to the suture; the lower surface is almost planate and almost horizontal but is strongly upturned to the axis. The lateral and lower surfaces meet in a rounded peripheral angle about two-thirds of the entire height of the volution below the suture. The peripheral angle is indented by the slitband which is defined by two slender sharp revolving lirae of equal size and prominence. The volutions embrace about to the lower boundary of the slitband which, rising sharply above the suture, gives the spire a slightly turreted shape.

The sculpture varies considerably, but that of the lateral surface in general terms consists of 7 to 9 revolving lirae surmounted by rounded nodes regularly spaced at about their own diameter. The lirae are on the whole equal in size and regular in arrangement, but they are commonly a little

finer and more closely arranged above, near the suture, and a little coarser and more widely spaced below, near the slitband. For a short distance below the suture the nodes have a transverse as well as a spiral arrangement.

The lower surface is marked by from 7 to 13 slender, sharply elevated revolving lirae separated by flattened interspaces. In contrast to those of the lateral surface, these lirae are smooth, devoid of nodes or even, as a rule, of crenulations. Toward the axis, thev do not so much diminish in size as in spacing, the interspaces near the periphery being somewhat wider than the lirae, those near the axis somewhat narrower.

The slitband, as already described, is a narrow sulcus indenting the peripheral angle and defined by two slender lirae. These lirae are smooth and knife-edged. The upper one contrasts strongly with the nodose lirae just above; the lower one, on the contrary, rarely differs appreciably from the lirae of the lower surface except that it is so situated and directed as to make the lower surface appear to terminate there in a sharp angle. The slitband is regularly divided by a slender median lira formed of small, closely arranged nodes. Though resemling the lirae of the upper surface in its moniliform shape, this lira is more slender and more finely nodose.

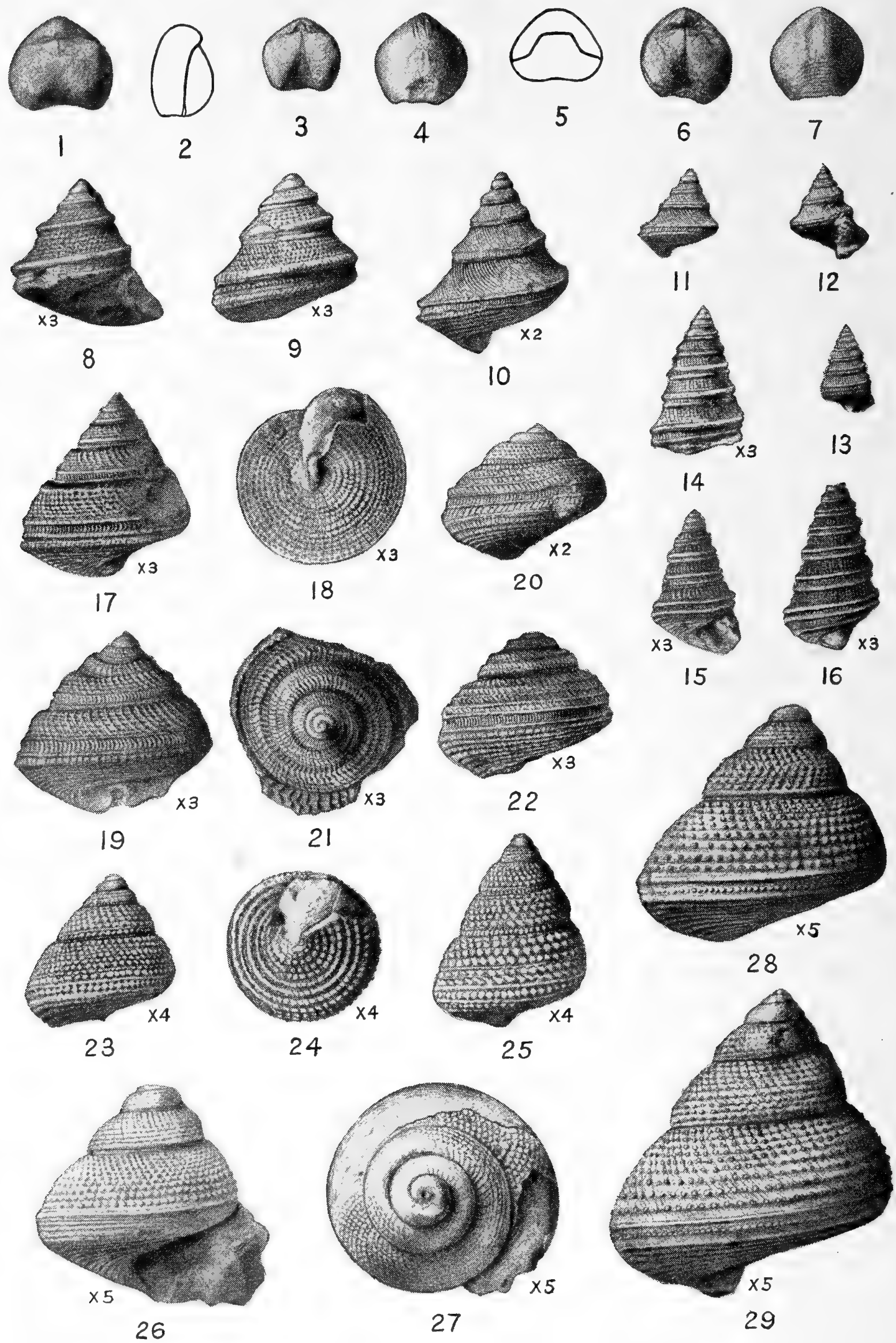
The axis is solid. There is no inner lip; instead, the surface of the final whorl within the aperture is smooth and depressed as if the shell had been removed by absorption.

The slit was probably shallow though it has not actually been observed. This inference is suggested by the fact that structure is not shown by specimens which appear to be but little broken at the aperture. Either the slit must have been short or the breakage greater than it appears to be.

This species is by no means rare and the numerous specimens examined show considerable variation. Shells have been referred here that differ notably both in the width of the spiral angle and in the shape of the constituent whorls. In some, the lateral and lower surfaces of the whorls are less arched than in others; the lateral surface may flare in the lower part with a prominent edge to the slitband below it; and rather commonly the lira that bounds the slitband above is a little stronger and more prominent than the one below it.

The relation between the lirae and the interspaces on the lateral surface is variable; the lirae may be relatively thick and the interspaces about equal to them or a trifle smaller; or the lira may be relatively slender and the interspaces correspondingly broad. Small accessory lirae may occur here and there in the interspaces, bringing the total number up to 12 or more in some instances. The size of the nodes and the size of the lirae vary pari passu. The accessory lirae have smaller nodes than the regular lirae and if extremely slender they may have no nodes at all. The slitband is sometimes distinguished not only in the ways mentioned, but also by being isolated, the interval between it and the lowest lira above being as wide as the slitband itself and much wider than the interval between any of the nodose lirae. On the other hand, this interval may be occupied by a slender accessory lira. The relation between the lirae and interspaces varies also on the lower surface, some specimens having slender lirae with relatively wide interspaces, others relatively thick lirae with narrow interspaces.

The nodose character of the revolving lirae is virtually due to slender transverse ridges developed at short and regular intervals which, on crossing the revolving lirae, greatly strengthen them. These transverse elements are rarely to be distinguished as ridges except below the suture; elsewhere they



Figs. 1–29.—For explanation see opposite page.

are almost without visible evidence save that which is furnished by the nodes. Consequently, the spiral arrangement of the nodes is conspicuous, the transverse arrangement readily overlooked. Nevertheless such an arrangement must be present if the nodes are formed in the manner indicated, and in fact, upon close observation, transverse rows can be distinguished, curved and backward sloping. Except near the suture and for occasional prolongations, very subdued, the transverse ridges do not appear elsewhere on the older volutions. They are suggested, it is true, by the nodes on the median lira of the slitband, but the slitband rarely shows any evidence, even obscurely, of the sharply defined lunettes characteristic of that part, whereas the lower surface commonly appears to lack even growth lines.

With well preserved specimens and with a favorable light, the nodes on the lateral surface are seen to have the form of arched scales rising obliquely toward the aperture and in general appearance they may be likened to a series of minute funnels issuing one from another. They appear to be produced by transverse lamellae that are extended and thickened where they cross the revolving lirae. On the same specimen, but with a change of light these projections look like well defined rounded nodes, and that is how they usually appear.

As the shell progressed toward maturity the volutions underwent a change both in shape and in sculpture. The immature whorls were essentially circular in section, but the later ones became flattened on the outer side obliquely and on the under side horizontally until they became more or less rhombic in section. The immature sculpture was characterized by a greater balance between the transverse and spiral markings. At a stage preceding that characterized by a mature type of sculpture the transverse lirae and the spiral lirae appear to have been of about equal strength. Not un-

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Description of figures

The figures on this plate are of natural size unless otherwise stated.

Figs. 1–7. *Cryptacanthia? robusta* n.sp. Different views of 4 cotypes. Figs. 1–2. Dorsal and side views of a large specimen somewhat worn down the middle of the pedicle valve. Fig. 3. Dorsal view of a small specimen. Fig. 4. Ventral view of another specimen. Figs. 5–7. Anterior, dorsal, and ventral view of a fairly complete specimen. Delaware Mountain formation, Culberson County, Texas (station 6452).

Figs. 8–9. *Pleurotomaria worthenioides* n.sp. Two views of the holotype, ×3. Brentwood limestone, Winslow quadrangle, Arkansas (station 3733).

Figs. 10–12. *Euconospira hermosana* n.sp. Three views of the holotype, figure 10 being ×2. McCoy formation of Roth, McCoy, Colorado (station 6714).

Figs. 13–16. *Pleurotomaria rockymontana* n.sp. Views of 4 cotypes. Figures 14–16 are ×3. McCoy formation of Roth, McCoy, Colorado (station 6714).

Figs. 17–19. *Orestas? reticulatus* n.sp. View of 2 of 4 cotypes. ×3. The specimen represented by figure 19 is not only crushed, but as drawn is somewhat tilted, giving a false impression of the configuration in several respects. The under side is really almost flat and almost horizontal, as in figure 17. McCoy formation of Roth, McCoy, Colorado (station 6714).

Figs. 20–22. *Orestes? quadrilineatus* n.sp. Views of 3 of 4 cotypes. Fig. 20 is ×2, the others ×3. McCoy formation of Roth, McCoy, Colorado (station 6714).

Figs. 23–25. *Pleurotomaria aspera* n.sp. Views of 2 of 4 cotypes. ×4. Figures 24 and 25 represent the same specimen. McCoy formation of Roth, McCoy, Colorado (station 6714).

Figs. 26, 27. *Pleurotomaria woolseyana*, n.sp. Views of 1 of 7 cotypes, ×5. The median lira of the slitband is marked by minute nodes, too small to be represented on the drawing. Brentwood limestone, Winslow quadrangle, Arkansas (station 2849).

Figs. 28, 29. *Pleurotomaria millegranosa* n.sp. Views of 2 of 7 cotypes, ×5. Brentwood limestone, Winslow quadrangle, Arkansas (figure 28, station 3733; figure 29, station 3662).

commonly the upper half of the volution will appear to be marked by transverse lirae rendered irregular or nodose by the spiral lirae while the lower half appears to be marked by spiral lirae rendered regularly nodose by the transverse lirae. At one stage, probably just prior to the stage just described, the surface is marked by smooth spiral lirae of considerable strength and at a stage still earlier by minute irregular spiral striations. The earliest stages were presumably smooth or marked only by incremental lines.

These specimens show a feature which they share with many other gastropods, but which cannot be accounted for in any acceptable way. I refer to small round openings or perforations which are obviously superficial as regards penetration, fairly uniform in size, and fairly regular in distribution. That is, although they are found only on certain specimens and on certain parts of others, they almost invariably occur on the tops of the nodes or on the crests of the lirae. They can hardly be attributed to a boring organism or on the other hand to abrasion. It is conceivable that they may be due to some peculiarity of structure or to some peculiarity of chemical composition (perhaps related to the pigments that produced color markings) and that variation in this feature was played upon by varying forces in process of fossilization. As this phenomenon is so common it is mentioned here only because it sometimes lends a fictitious appearance to those lirae of the lower surface which are described as smooth and even, but are in this way made to appear ragged or nodose.

P. millegranosa was found in considerable abundance at station 3662 and station 3733, and a single characteristic specimen was found at station 1996d. Elsewhere the species appears to be rare and the other specimens referred here are few, immature, and more or less ill-preserved. Their identification is correspondingly qualified.

Pleurotomaria millegranosa resembles Meek and Worthen's *P. granulistriata* from which, however, it differs considerably in several particulars. The whorls in *P. granulistriata* appear to be more regularly rounded and the lateral surface is traversed by only 3 or 4 revolving lines, whereas *P. millegranosa* has twice that number. The transverse lines which in both species help to produce the granules on the revolving lirae are in *P. granulistriata* more pronounced; in the present species the granules (except in young specimens) rarely show much transverse connection and are predominantly spiral in their arrangement. Furthermore in *P. millegranosa* the lower surface has somewhat more numerous revolving lirae and it is also without cross striae. These differences and others show clearly that *P. millegranosa* is a distinct species. It is also distinct from the one which I have called *Pleurotomaria woolseyana,* though an undoubted resemblance exists between them. The slitband in *P. millegranosa* is narrower and more sharply defined and it is traversed by a single lira which bears regular nodes instead of several smaller lirae which commonly are without them and the lateral surface is even less conspicuously marked by transverse lirae.

Brentwood limestone member of the Bloyd shale (early Pennsylvanian); S.W.¼ sec. 27, T.13N., R.32W. (station 3733); up draw from Cove Creek, 3 miles north of Cold Spring, Arkansas (station 3662). Winslow quadrangle.

ZOOLOGY.—*A new pocket mouse from Sonora.*[1] E. W. NELSON, U. S. National Museum and E. A. GOLDMAN, Biological Survey.

Among the results of the Mexican expedition of Frederic Winthrop in cooperation with the Biological Survey in 1932, was the collection of a specimen of *Perognathus flavus* in Sonora. The known range of the species is thus materially extended into the low desert region near the shore of the Gulf of California. The single specimen collected appears to represent a new and easily recognizable geographic race here described.

Perognathus flavus sonoriensis, subsp. nov.
Sonora Pocket Mouse

Type.—From Costa Rica Ranch, lower Sonora River, Sonora, Mexico. No. 250885, ♀ adult, skin and skull, U. S. National Museum (Biological Survey collection), collected by Vernon Bailey and Frederic Winthrop, December 13, 1932. Original number 11282.

Distribution.—Low desert plains of middle western Sonora.

General characters.—Closely allied to *Perognathus flavus flavus*, but upper parts less heavily overlaid with black, owing to shortening of dark tips of hairs; ears less blackish; black facial markings obsolescent; hind foot apparently shorter; cranial details distinctive.

Color.—*Type:* Upper parts in general near pinkish buff (Ridgway, 1912), finely mixed or overlaid with black, the dark hairs most numerous on top of head and over back; lateral line rich pinkish buff, broad and distinct from cheeks to thighs, with a narrow downward extension reaching to near forearm; under parts and limbs white; muzzle white; dark, V-shaped, facial marking narrow and indistinct; ears lined internally with mixed grayish and brownish hairs; tail dull whitish, nearly unicolor.

Skull.—Very similar to that of typical *flavus*, but rostrum and nasals shorter; zygomata more widely spreading anteriorly; molariform teeth smaller.

Measurements.—*Type:* Hind foot, 15 mm. (no other external measurements available). *Skull* (type): Length (median line), 19.3; greatest breadth (across audital bullae at meatus), 11.7; zygomatic breadth (posteriorly), 10.3; interorbital breadth, 4.2; length of nasals, 6.5; width of nasals (in front of incisors), 2; interparietal, 3×3.2; maxillary toothrow, 2.8.

Remarks.—*P. f. sonoriensis* requires close comparison only with typical *flavus* of western Texas. Vernon Bailey reported that the specimen made the type "was found dead, drowned after the big rain of December 14, near our camp on the big flat at the sink of the Sonora River." In regard to the general occurrence of the animal he says: "On the big sandy mesquite plains near Llano they were especially numerous and dozens of their characteristic little round burrows and little hills of earth were all around our camp . . . but the mice refused our bait. One left his tail in a trap which showed the species if not the subspecies. Other places where signs were seen were near Hermosillo and Magdalena."

[1] Received March 14, 1934.

ENTOMOLOGY.—*The genus* Oliarus *and its allies in North America* (*Homoptera Fulgoridae*).[1] E. D. BALL, University of Arizona.

The writer started to prepare a food plant list of the western wax-hoppers of the Fulgorid family *Cixidae* but soon found that, as usual, a considerable number of the species had apparently not been named. As opportunity afforded he has been taking up one genus at a time for preliminary revision in order to assign the new forms to their proper positions. One form was found that did not fit into any existing genus and the following genus is proposed for its reception.

Oliaronus Ball n. gen.

Intermediate in size and form between *Mnemosyne* and *Oliarus*. Resembling a large dark *Oliarus* with an extremely broad head and long, narrow, almost parallel margined elytra. Vertex very broad, but little longer than broad, almost parallel margined, the lateral carinae angled just in front of the middle and uniting before the apex, forming two large fovae. Front tumid, rounding over to vertex with only a trace of a carina, broad at the base and narrowly clasping the extremely long, oval, tumid clypeus. The ocellus visible and a median carina on front and clypeus indicated. Pronotum as short or shorter than in *Oliarus*, deeply angularly emarginate posteriorly and projecting into the angularly emarginate head. Mesonotum faintly 5 carinate. Elytra long and narrow with a smoky subhyaline membrane and strong dark nervures that are heavily setigerous throughout. Venation striking and distinctive. The subcosta (+R) approaching the costa which is thickened back to the stigma and the whole thickened area thickly beset with heavy setigerous punctures. The area between the subcosta and medius with scattering punctures in the central part. The stigma located anterior to the end of the clavus, the subcosta and radius both turning in, the subcosta capturing the radius about half way back from the stigma and thus forming a very broad area along the costa, which is divided into from 8 to 10 long narrow transverse cells. The female abdomen with a large wax plate.

Type of the genus *Oliaronus tontonus* n. sp.

Oliaronus tontonus Ball n. sp.

Superficially resembling *Oliarus pima* Kirk, slightly longer and narrower, much darker and more heavily setigerous; with a series of transverse veinlets back of the stigma. Length ♀ 10 mm, ♂ 8 mm, width ♀ 3.5 mm.

Structure of the genus, the vertex almost square, rounding over in front, face much narrower than in *O. pima* and more tumid. Pronotum very short, not more than half the length of that in *pima*, the carina closely margining the eyes. Elytra long, narrow, and appressed, the apical third slightly expanded, the costal margin with a slight angle near the base, the costal area back of this very narrow, darkened and heavily pustulate. The stigma very short and placed far forward, only a little farther from the base than the apex. Behind this in the expanded area are 8–10 long narrow transverse cells becoming more oblique as they approach the apex.

[1] Received February 28, 1934.

Color, dark smoky brown, the face, margins of vertex and often the mesonotal tablet testaceous; elytra smoky, the nervures black.

Holotype ♀, allotype ♂, and 10 paratypes Eloy, Ariz., Aug. 5, 1932, one Cline, Ariz. Aug. 2, 1929, all taken from mesquite by the writer; one paratype, Florence July 25, 1932 (Parker). The transverse cells in the expanded margins of the elytra will at once distinguish the species.

Genus Oliarus Stal

The genus *Oliarus* was a difficult one for all early American workers because the amount of material available was very limited and fragmentary, many species being represented by a single individual or a single sex and good series from a single food plant unknown. Five species were named by the early workers. The writer described three western species in 1902. Fowler in the Biologia (1904) described nine new species without recognizing any of those previously described. His material was very limited, half of the species being described from a single sex. Van Duzee reviewed the United States forms in 1908 with the first key and added several species in 1912, and others later. Metcalf (1923) keyed out the species of the eastern United States and added four more.

The writer has been collecting material and attempting to determine food plants during the thirty years since his first paper, and now has good series of twenty-three and representatives of three others of the twenty-eight species here recognized as occurring north of the Mexican border. A study of long series of a number of species has brought out the fact that in this genus the females may be transversely banded, striped, or spotted but the corresponding males are nearly always plain or nearly so. This has not been previously recognized and has led to much confusion and synonomy.

A careful study of Fowler's descriptions and figures suggests the following disposition of his species; *O. excelsus* belongs to the *vicarius-placitus* group but cannot be placed accurately until a male is found. It appears to resemble *placitus* Van D. and examples of that species are at hand from Brownsville, Tex. *O. concinnulus* appears to be a distinct species occurring in the U. S. *O. propior* seems to be a distinct species of the broad headed group; the figure shows an extremely broad face. *O. lacteipennis*, poorly described without sex is apparently *complectus* Ball (1902). *O. humeralis*, equally poorly described from a female, is probably the same. *O. breviceps* described from a female is *aridus* Ball (1902) which occurs commonly around the Gulf. *O. chiriquensis* and *insignior* belong to the genus *Myndus* and are apparently distinct species in that group. *O. nigro-alutaceus* is a distinct species occurring north into Arizona.

Metcalf (1923) did not recognize the difference in color between sexes which is so striking in this group, nor did he consider the Fowler species and as a result redescribed *concinnulus* Fowl. as *texanus* from Brownsville. The writer took a good series there in Jan., 1932. Fowler's drawing of the genitalia is much better than Metcalf's figure. Metcalf apparently misidentified *diffi-*

cilis Van D. which was described from two females, as he figures the male genitalia as of the "hammer" type. The writer collected in central and southern Florida and at Brownsville, Tex. a small pale species the female of which exactly fits Van Duzee's description of *difficilis* and the male of Metcalf's description of *vittatus* (holotype male) from Brownsville. The allotype ♀ of *vittatus* described with the broad vitta was the female of *texanus* (which = *concinnulus* Fowl.), while the true female of *vittatus* (which = *difficilis* Van D.) has the remnants of a transverse band as described by Van Duzee.

PRELIMINARY KEY TO THE SPECIES OF OLIARUS

A Female with more or less definitely transversely banded elytra (often three dashes on costal area). Verticies rather long, narrow, deeply sunken between high lateral carinae that are alternately light and dark. (Male genital projections sometimes greatly enlarged at apex.)
  B Male genital projection enlarged, plates hammer like .... (Fla. Tex.) 1. *placitus* V.D. (N.C.) 2. *montanus* Metc.
  BB Male genital projection triangular.
    C Nervures all heavily dotted. Species large .... (SE) 3. *vicarius* Wk. (NE) 4. *quinquelineatus* (N.C.) 5. *vitreus* Metc.
    CC Nervures on the basal half of elytra pale, punctures scarcely showing. Species small .... (Fla. Tex.) 6. *difficilis* V.D. (Fla.) 7. *chuliotus* Ball
AA Females with markings on elytra more or less linear (or oblique) or obscure (no dashes along the costal area, *exoptatus* excepted). Vertex variable, often broad and shallow, male genital projection never enlarged.
  D Species broad, often short and broad, the vertex as broad as long or not over one third longer than broad.
    E Elytra smoky. Females often with dashes along costa and occasionally a transverse band.
      F Elytra uniformly smoky, face definitely carinate .... (NW) 8. *exoptatus* V.D.
      FF Elytra deep smoky, twice interrupted with white. Face tumid, polished .... (Ariz.) 9. *papagonus* Ball
    EE Elytra hyaline, costal area immaculate.
      G ♀ 8–10 mm. Elytra milky, the nervures darkened but scarcely punctured.
        H ♀ 10 mm. Elytra with markings .... (Ariz.) 10. *pima* Kirk
        HH ♀ 8 mm. Elytra more or less ornamented .... ♀ (Ariz.) 11. *nogalanus* Ball (South) 12. *aridus* Ball
      GG ♀ 7 mm. or less. Elytra various.
        I General body color dark.
          J ♀ with a heavy zig zag pattern on elytra .... (SW) 13. *californicus* V.D.
          JJ ♀ almost unmarked.
            K Face tawny with large spots .... (Western 14. *hesperius* V.D. (Calif.) 15. *truncatus* V.D.
            KK Face black, unmarked. Stigma small .... (Calif.) 16. *fidus* V.D.
        II General body color tan or lighter .... (Colo.) 17. *sementinus* Ball

DD Species more or less elongate, the vertex more than $\frac{1}{3}$ longer than broad.
L Elytra hyaline or subhyaline, not deeply smoky.
M Body dark (or brown). The nervures dark or dark punctured.
N Elytra with the apical nervure and margin concolorous with the adjoining nervures.
O The nervures of the elytra only faintly or sparsely dotted or else the nervures dark so that the punctures are obscure.
P Front more than twice as broad across the antennae as at base. Faun colored with a pair of yellow spots. Large...(Fla.) 18. *slossoni* V.D.
PP Face much narrower, not twice wider on antennae than at base, dark with the carinae light.
Q Large (3 mm. broad) Dark with the nervures dark throughout.................(Ariz.) 19. *corvinus* Ball
QQ Smaller (2 mm. broad) paler or dark with the nervures pale.
R Spine of anal segment of ♀ produced into an acute point extending into the genital cavity, 3rd anteapical cell wanting, the fourth very broad at apex...............................Subtropical) 20. *complectus* Ball
RR Anal segment of male without a spine extending into genital cavity.
S 6 anteapical cells, the third but little longer than wide.......................(Ariz.) 21. *yavapanus* Ball
SS 5 anteapical cells the third wanting...................................(Ariz.) 22. *coconinus* Ball
OO The nervures at the base of the elytra pale, heavily and evenly dotted.
T Elytra slightly tawny or smoky, the dots and cross nervures not prominent.................(Fla.) 23. *littoralis* Ball
TT Elytra hyaline with heavy dots and cross nervures.
U Vertex broad at base, the lateral fovae not half its length.............................24. *concinnulus* Fowl.
UU Vertex narrow, the lateral fovae more than half its length............(Ariz. & Mex.) 25. *apache* Ball
NN Elytra with the apical margins narrowly ivory; the nervures, at least on the apical portion, dark with heavy bristles....................................(Ariz.) 26. *altanus* Ball
MM Body tawny, the nervures pale except at apex..(Arid W.) 27. *dondonius* Ball
LL Elytra deep smoky or black, or at least the apical third dark.
V Elytra all smoky.
W Small (not 2 mm. wide) costal margin of elytra dark.............................(SW & Mex.) 28. *nigro-alutaceus* Fowl.
WW Large (4 mm. wide) costal margin narrowly white...................................(North) 29. *cinnamomeus* Prov.
VV Apical third of elytra deep smoky.....(North) 30. *humilis* Say

Oliarus chuliotus Ball n. sp.

Size and form of *difficilis* Van D. nearly, slightly smaller and decidedly whiter. Length 4.5–5 mm.

Vertex slightly longer and narrower than in *difficilis,* the front much nar-

rower with the basal fork of the carina subobsolete, the front slightly longer than the clypeus, while in *difficilis* it is reversed. Mesonotum with the five carinae distinct, while *difficilis* shows only three. Male styles short and stout with a stout hook at right angles extending one third of their length beyond the short pygofers. In *difficilis* the styles are longer, the hooked portion shorter and stouter and the whole not extending beyond the elongated pygofer margins.

Color pale cinnamon brown above and below; the face without white spots, an elongated white spot on the carinae of vertex, the anterior fovae black, a dark brown area outside the lateral carinae of mesonotum. Elytra milky subhyaline over a dark abdomen; the apical third slightly smoky with the transverse nervures infuscated with brown; sometimes a brown cloud inside the stigma. In the females, an elongated black spot back of the middle of the commissure.

Holotype ♀ April 17, 1927, allotype ♂ Apr. 18, 1927, paratype females Apr. 17, 1927, and Apr. 15, 1928, all taken by the writer at Sanford, Fla. A female, Homestead, Fla., May 15, 1928. A male, Eustice, Fla. Apr. 6, 1926, taken by the writer and a male, Haw Creek, Fla., Oct. 8, 1887. Strikingly distinct in color and genitalia.

Oliarus papagonus Ball n. sp.

Resembling *exoptatus* Van D. but slightly smaller, darker with rather indefinite white bands across the elytra. Elytra smoky, face and mesonotum black, polished with the carinae obscure. Length 4–5 mm.

Vertex narrower than in *exoptatus* or *fidus* Van D., a little longer than wide, parallel margined instead of broadening behind as in those species. The basal tablet of vertex narrow and forming a long oval in front, instead of very broad and almost truncate before the tumid apex as in the species mentioned. The whole face evenly convex, polished with the carinae almost obsolete. Mesonotum broad, tumid, polished with obscure carinae. Elytra broad, short, with prominent nervures and heavy setigerous bristles. Male styles with the reflexed portion little wider than the shank and only slightly exceeding the pygofers, the dorsal membrane broad and elevated into a roof-like structure over the styles.

Color, dark smoky, with indistinct white bands across the elytra. Face and mesonotum shining black, the latter margined outside with white. Vertex dark, the carinae rather broadly light.

Holotype ♀, allotype ♂, and 13 paratypes Eloy, Ariz., June 3, 1933, all taken by the writer from a few mesquite trees growing in an area where *Lycium sp.* was abundant.

Oliarus nogalanus Ball n. sp.

Smaller and narrower than *pima* Kirk, the female more definitely ornamented, resembling *aridus* Ball but darker and more slender, much more heavily clothed with setigerous bristles than in either of the others. Length 6–8 mm., width 2 mm.

Vertex, within the carinae and omitting the fovae, as long as wide instead of wider than long as in *aridus* or nearly twice wider than long as in *pima*. Face slightly narrower than in *aridus*. Male styles with the shanks narrow and the hooked portion broad and roundingly right angled, extending considerably beyond the short rounding lateral margins of the pygofers. The dorsal membrane very short and rounding with a slight elevation in the

center. In *aridus* the styles are acutely angled, the pygofers long and the dorsal membrane projects in a long triangle, while in *pima* the hook is still thicker and the dorsal membrane is both longer and broader.

Color brown; a pair of creamy spots on margins of face just below the antennae; the carinae of vertex and pronotum white, elytra in female slightly milky, the nervures dark, the bristles darker, with the forks and cross nervures marked with smoky, which in heavily marked individuals coalesces into two oblique bands toward the apex.

Holotype ♀, Nogales, Aug. 7, 1932, allotype ♂, Santa Rita Mts., July 19, 1931, and 14 paratypes taken with the types and from Douglas, Patagonia and Tucson. All taken by the writer in the mountains of Arizona.

Oliarus corvinus Ball n. sp.

Resembling *complectus* Ball, but larger and darker with heavy pilosity. Black with the carinae orange. Length 5–6 mm.

Vertex relatively long and narrow with the fovae long, slender, reaching the middle of vertex. Base of front narrower and more heavily carinate than in *complectus*. Pronotum larger and more heavily carinate than in *complectus*, elytra longer with the nervures darker and more heavily clothed with setigerous punctures. The third anteapical either reduced or wanting, the fourth about as wide as the adjoining cells instead of much wider as in *complectus*. Male styles stout, the hook broad, evenly rounding, exceeding the truncate pygofers by nearly their width. Dorsal hood moderately broad and almost evenly rounding except for a slight central depression, instead of rather narrow and acutely produced into the genital cavity as in *complectus*.

Color black, all carinae broadly orange. Elytra hyaline or slightly smoky, the nervures dark and heavily clothed with dark hairs. Genitalia cinnamon.

Holotype ♀, allotype ♂, and 12 paratypes, Patagonia Aug. 8, 1932. This species is widely distributed in southern Arizona and is easily distinguished by its size.

Oliarus complectus Ball

O. complectus Ball Can. Ent. **34**: p. 152. 1902.

(*O. lacteipennis* Fowl. Bio. Cent. Am. Homop. Vol. 1, p. 93. 1904)

(*O. humeralis* Fowl. op. cit. p. 94)

(*O. franciscanus* V.D. Cat. p. 732 [Not Stal])

This species was described from 25 examples from Haiti, Md., Kans., Ariz., and Colo. The present study brings out the fact that there were at least two and probably three species included in the original material. In order to definitely limit it to the species intended in the original description, the holotype is fixed on a female from Port Au Prince, Haiti, and the allotype on a male from the same place, both examples so labeled and in the author's collection.

Thus limited the species may be known by the fact that the anal segment projects down into the genital cavity in the form of a median spine. Examples are at hand from Haiti, many places in Florida, southern Arizona and adjacent Mexico. Van Duzee places this species as a synonym of *franciscanus* of Stal, largely on size and distribution no doubt, as Stal's description is

purely generic. As there are at least four species treated in this paper that would meet these requirements, it seems best to consider Stal's species as unknown until such time as our west coast forms are better known and Stal's type can be critically studied.

Oliarus yavapanus Ball n. sp.

Resembling *complectus* but with a narrower vertex, and 6 anteapicals, paler with smoky elytra. Length ♂ 4 mm.; ♀ nearly 6 mm.

Vertex twice longer than wide, the fovae scarcely half its length, the lateral carinae high, almost foliaceous. In profile the vertex and face form a slightly obtuse angle. Mesonotum with five definite carinae, the inner pair strongly sinuate and together with the outer pair enclosing an oval compartment posteriorly. Elytra long and slender, six apical cells the third little longer than wide. Male with the anal segment forming a narrow and uniformly rounding hood back of the long, narrow, angularly hooked, dark brown styles.

Color dark brown to black, the carinae broadly orange, elytra slightly smoky in females, rarely so in the males. The darkening emphasized on the apical cells. The nervures distinctly but not conspicuously punctured. The stigma not as prominent as in *complectus* or *corvinus*.

Holotype ♀, allotype ♂, and a pair of paratypes, Ashfork Aug. 16, 1929, six paratypes Ashfork July 15, 1929, three Yarnell Heights July 21, 1929, and two from the same place Aug. 20, 1929. All collected by the writer from the higher table lands or mountains of Arizona.

Oliarus coconinus Ball n. sp.

Stouter than *complectus* Ball, resembles *yavapanus* Ball, but with a broader vertex and only five anteapicals. Female elytra heavily smoky posteriorly; male hyaline. Length ♂ 4.5 mm.; ♀ 5.5 mm.

Vertex broader behind than in *yavapanus* especially in the female. In profile the vertex meets the front in a right angle. Elytra long and slender with five anteapical cells, the fourth scarcely broader than the others, the stigma elongate. Male anal hood broad on the lateral margins, deeply emarginate medially, where it is distant from the short, stout, bright yellow styles that terminate in round slightly divergent plates.

Color dark brown or black, the carinae narrowly orange. Elytra smoky in the female especially on the transverse nervures, hyaline in the male, nervures dark, sparsely and inconspicuously ornamented with setigerous punctures. A dark line along the median portion of the sutural margin.

Holotype ♀, allotype ♂, and one male paratype Williams July 13, 1929, a female Aug. 15, 1929, a female Flagstaff Aug. 7, 1929, and two males Huachuca Mts., Aug. 2, 1931, all taken by the writer from the table lands or mountains in Arizona.

Oliarus littoralis Ball n. sp.

Form of *complectus* Ball nearly, slightly shorter and stouter, resembles *sementinus* Ball in form and color, but with a much longer, narrower head. Pale brown with the carinae light; elytra pale tawny with the nervures punctured and darker towards apex. Length 4.5 to 5.5 mm.

Vertex and mesonotum about as in *yavapanus* Ball, the elytra with six anteapicals, punctures on nervures strong and extending almost to base.

Male anal segment broad and emarginate as in *coconinus* Ball, the styles stout with long angularly reflexed heads.

Color, pale tawny; the vertex and mesonotum pale to dark brown with the carinae broadly light. Front and clypeus dark brown or darker, but with the carinae broadly light. Elytra tawny subhyaline, the nervures pale tawny and heavily punctured to the cross nervures beyond which they shade to smoky.

Holotype ♀, allotype ♂, and seven pairs of paratypes taken by the writer at Tampa, Fla. Sept. 10, 1927. This tawny species resembles *dondonius* but is much darker, with the styles broader and more hairy, the hood with the lateral flaps overhanging the genital chamber, while in *dondonius* the hood is only a marginal line. Besides the type set, the writer has taken this species in a number of places along the east coast of Florida.

Oliarus concinnulus Fowler

O. concinnulus Fowl. Bio. Cent. Am. Homop. Vol. 1, p. 92. 1904.
(*O. texanus* Metc. Journ. El. Mitch. Sci. Soc. **38**: 181. 1923)
(*O. vittatus* (♀) Metc. Op. cit. 181. [Not holotype ♂])

This is a short broad species, (4–6 mm.), but the vertex is more than $\frac{1}{3}$ longer than its width. The elytra are milky with heavily punctured nervures, pale at the base but becoming dark beyond the cross nervures. The stigma is large and there are usually two black spots in an oblique line from it to the scutellum. The female often has a broad, longitudinal, slightly interrupted stripe near the inner margin of each elytron.

Habitat, Vera Cruz and Guerrero, Mexico (Fowler) and Brownsville, Texas. Fowler suggested that this species may have to be referred to *O. lunatus* Fab. as represented by material which the writer sent him. That material, however, represents a very distinct species.

Oliarus apache Ball n. sp.

Resembling *concinnulus* Fowl. in size and form, darker with a narrower vertex. Black with the carinae on head narrowly light. Elytra milky with close set, black punctures, each bearing a long curved black hair. Length 4–6 mm.

Vertex much narrower than in *concinnulus*, the fovae long, extending more than half way to base. Mesonotum with three, heavy, parallel carinae, the intermediate pair only faintly indicated. The anal segment much more extended than in *concinnulus*, the styles more slender and asymmetrical, the left one larger and slightly notched at apex.

Color black above and below, the carinae on vertex and pronotum narrowly light, a pair of white spots on the carinae between the eyes and another pair on the extended apical margins of the front. Mesonotal carinae concolorous or slightly orange, elytra milky, the nervures white throughout, except the marginal nervures, heavily and closely punctured with black and clothed with long curved black hairs. The forks and cross-nervures broadly black. The stigma coriaceous white except for aggregated punctures on the boundary nervure.

Holotype ♀, allotype ♂, and 4 paratypes May 15, 1933 and nine paratypes May 19, 1929, all taken by the writer at Tucson, Ariz. This strikingly

distinct species has been taken in the Creosote deserts around Tucson, at Patagonia and Tinajas Altas in Ariz. and near Hermosillo, Mexico.

Oliarus altanus Ball n. sp.

Resembling *apache* Ball, but longer, slenderer with extremely long narrow elytra, and coarse irregular veins that are definitely black in the apical region against the broad white margin. Length 5 mm.

Vertex slightly broader and deeper than in *apache*, the front longer and narrower. Elytra extremely long and slender, the inner fork of the radius approaching and paralleling the medius for some distance, nervures and cells in the apical portion tending to irregularity with the third apical narrow and curved. The stigmal cell extremely long and narrow, four times as long as its width.

Color, black, the bounding carinae, except on mesonotum, narrowly light, median carinae of front tawny, a pair of semi-circular white spots on the carinae adjacent to the eyes. Elytra milky white, the bounding nervure broadly white, the remaining nervures either all dark or dark spotted at base and all dark towards apex in striking contrast to the margin.

Holotype ♀, allotype ♂, and two male paratypes taken by the writer at Tinajas Altas, Ariz. May 17, 1932.

Oliarus dondonius Ball n. sp.

Resembling *sementinus* Ball in color, slightly smaller, but with a vertex one half as wide. Form of *yavapanus* Ball nearly, much paler with a pale stigma. Pale tawny with a castaneous mesonotum. Length 4.5–5.5 mm.

Vertex as in *yavapanus* nearly, the fovae narrowed, pronotum much shorter and rarely reaching the epaulets at the shoulders. Elytra slightly broader with only 5 anteapical cells and a narrow stigma, half longer than its basal width.

Color, pale tawny, the elytra paler. The face in the males, the lateral fovae and sometimes longitudinal stripes on the mesonotum, brown. Elytra with the nervures on the basal half indistinct, becoming tawny, towards the apex with the cross nervures smoky.

Holotype ♀, allotype ♂, and 10 paratypes, Tucson, Ariz. July 24, 1930, 4 paratypes, Grand Junction, Aug. 7, 1906, all taken by the writer on sea blite (*Dondia*). This species is common in alkaline areas from western Colorado through Utah to Arizona and Sonora, Mexico. It is a smaller and much narrower headed species than *sementinus* which it otherwise resembles.

ADVANCE SUMMARIES

BIOLOGY.—*Viability of bacteria in air.*[1] W. F. WELLS, Harvard School of Public Health. (Communicated by W. H. BRADLEY.)

A technique has been devised for study of the viability of droplet nuclei infection in air, by determining the differential disappearance rates in a controlled atmosphere of the infection and of the nuclei, and will be described more fully in a later publication. Preliminary experiments demonstrate that

[1] Presented before Section N. of the American Association for the Advancement of Science, Dec. 27, 1933. Received April 24, 1934.

the viability of pathogenic micro-organisms constitutes a more important limiting factor in the localization of droplet nuclei infection than does the rate at which droplet nuclei settle from the atmosphere.

Since the rate of fall of small droplets is proportional to the surface, and the rate of change of surface is constant, the distance a small droplet falls before ceasing to be a droplet is proportional to the fourth power of the diameter. Droplets less than 0.1 mm. in diameter, expelled from the nose or mouth, will dry under ordinary atmospheric conditions before reaching the ground. Droplet nuclei from broth culture of *B. subtilis*, atomized into a still chamber of 200 cubic feet capacity, were recovered from the air after several days. Though resistant organisms could be recovered from the air of the experimental chamber up to a week after inoculation, Pfeiffer's bacillus was not recovered after one hour.

Four organisms typical of infections of the passages of the upper respiratory tract, *B. pneumoniae, B. diphtheriae, Streptococcus hemolyticus* and *Streptococcus viridans,* were recovered from the air in small numbers forty-eight hours after inoculation, although in rapidly decreasing numbers. Organisms typical of the digestive tract, *B. coli, B. typhosus, B. paratyphoid A,* and *B. dysenteriae Hiss Y,* were not recovered after eight hours and were invariably absent at the end of the first day. Bacteriophage was recovered and identified after being suspended in air for 24 hours. It had decreased in a manner characteristic of microorganisms.

CONCLUSIONS

A distinction must be made between droplets, droplet nuclei, and dust, in considering air-borne infection. Droplets larger than 0.2 mm. are localized by rate of fall to the vicinity of the source both in time and space. Droplet nuclei derived from evaporation of droplets less than 0.1 mm. diameter are dispersed in time and space. Localization of dust also varies with the size of the particles. Droplet infection is largely localized and concentrated, whereas Droplet nuclei infection tends toward dispersion and dilution and the possibility of infection is limited in time chiefly by the viability of the microorganisms. Dust infection may be localized either in space by the localization of particles, or in time by the viability of the infection.

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

National Academy of Sciences.—The spring meeting of the National Academy of Sciences was held in Washington, April 23, 24 and 25, under the presidency of Dr. W. W. CAMPBELL. The principal evening address was delivered by Dr. EDWIN HUBBLE of the Mount Wilson Observatory of the

Carnegie Institution of Washington, on "The Realm of the Nebulae." Dr. HUBBLE described the present Observable Region as having a diameter of some 600 million light years, and containing approximately 100 million known spiral nebulae. A substantial enlargement of the Observable Region, the speaker stated, can be expected after the completion of the 200-inch reflector now under construction.

Spectrographic detection of large proportions of methane in the atmospheres of the major outer planets was announced at the meeting through a telegram sent by Director V. M. SLIPHER of Lowell Observatory, Flagstaff, Ariz. The tell-tale lines in the spectra of Jupiter, Saturn, Uranus and Neptune were interpreted in considerable part by Dr. ARTHUR ADEL of the University of Michigan. Presence of massive quantities of methane in the atmospheres of the giant planets has a possible significance for the still unsolved riddle of their surface temperatures, Dr. HENRY NORRIS RUSSELL of Princeton University said, in commenting on Dr. SLIPHER's telegram. At a temperature of −161.4 degrees Centigrade this gas becomes a liquid, unable to betray its presence through reflected light rays. Of course, under the different gravity and atmospheric-density conditions on the great planets the boiling point of methane might be different.

The intensity of a sound and its frequency are quite distinct physical attributes, but the corresponding psychological attributes of loudness and pitch are not so independent; a loud tone sounds lower in pitch than a high one, and a low tone sounds unduly loud, it was indicated by a report of the National Academy of Sciences delivered at the annual meeting by Dr. HARVEY FLETCHER, of the Bell Telephone Laboratories. It was found that a 50-cycle tone with an intensity which is 10,000 times that of a just barely audible sound appears just as loud as a 1,000 cycle tone with an intensity 1,000,000,000 times that of the threshold. The apparent pitch of a tone also depends upon its intensity. The pitch of a 200-cycle tone was heard as being as much as a quarter of an octave lower at the very high intensities than at the low intensities. However, when the tones were of very high frequencies, near 2,000 or 3,000 cycles, such changes of apparent pitch with intensity were not observed.

Distilled water, replacing ordinary tap water containing its usual quota of highly dilute mineral substances, produces anesthesia in plant cells, seemingly by dissolving out of them some unknown organic stuff. This observation was presented by Dr. W. J. V. OSTERHOUT and Dr. S. E. HILL of the Rockefeller Institute for Medical Research. When cells of *Nitella* are placed in distilled water they presently become completely anesthetic, transmitting no variations in potential along the protoplasm. This loss of sensitivity is hastened by the addition of acids or alkalis, but slowed by the addition of calcium. The anesthetic state passes off again when the cells are replaced in tap water.

Honored after his death, for his researches on the skull of ancient Peking Man, Dr. DAVIDSON BLACK was given the posthumous award of the Elliot Medal for 1931, which carries with it a cash honorarium of $200. Dr. BLACK was designated to receive the award before his death in Peiping on March 15; the medal and check were placed in the hands of Dr. FRANK DAWSON ADAMS, foreign associate of the Academy, on behalf of Dr. BLACK's widow. The first award of the Charles Doolittle Walcott Medal and honorarium of $1,350 was made to Dr. DAVID WHITE of the U. S. Geological Survey, in recognition of his work on the pre-Cambrian algae of the Grand Canyon of Arizona. Other

honors bestowed by the Academy were: the Agassiz Medal, awarded to Dr. BJORN HELLAND-HANSEN of the Geophysical Institute, Bergen, Norway; the Public Welfare Medal, awarded to Dr. DAVID FAIRCHILD, of the U. S. Department of Agriculture; and the Elliot Medal and honorarium of $200 for 1930, awarded to Dr. GEORGE ELLETT COGHILL, Wistar Institute of Anatomy and Biology, Philadelphia.

The American Geophysical Union.—Penetrating radiations resembling cosmic rays, but softer, are thrown upward into the air from the tops of thunderstorm clouds, like spray from the tops of waves. They come to earth again to the eastward of the cloud, drawn down by the earth's magnetic field. These radiations, which are made up of negative electrons, were described before the meeting of the American Geophysical Union here by Dr. B. F. J. SCHONLAND of the University of Capetown, who is visiting in the United States. Dr. SCHONLAND stated that when he began his investigations of penetrating radiations caused by lightning, he thought that he would find electrons poured directly earthward as well as upward into the higher levels of the air; but this proved not to be the case. He has found that lightning-engendered radiations can influence cosmic-ray detecting instruments as much as a thousand miles away from a thunderstorm, and he stated that another investigator claims for them an even greater radius of action. But their effect is always felt to the eastward of the storm that gives them birth, never toward the west. The research was undertaken with the idea of finding out whether cosmic rays were entirely the product of thunderstorms, as one student of the subject had claimed. Dr. SCHONLAND is convinced that this is not the case; nevertheless, there are enough lightning-caused penetrating radiations to make it necessary for researchers on cosmic rays to take them into account, if their figures are not to be falsified by thunderstorms.

New 40-inch reflector at Naval Observatory.—The new 40-inch reflector built for the U. S. Naval Observatory under the direction of GEORGE W. RITCHEY has been completed. The instrument is designed especially for spectrographic observation. Figured on new curves calculated by Mr. RITCHEY and HENRI CHRÉTIEN, it is expected to be as efficient as a reflector of several times its aperture based on the conventional paraboloid figure.

It is the first air cooled telescope. The entire observatory building is built of very light metal, with double walls, so that at night the temperature will soon become the same as the surrounding air. With more massive buildings, the stone and brick absorb heat all day, and give it off long into the night, producing objectionable air currents which spoil the clearness of the telescopic images. In order to keep the telescope at its night time temperature, a felt canopy will be placed over it in the daytime. This is connected with air cooling equipment, so that all day the telescope will be kept at the temperature expected that night.

The tube of the telescope is constructed with a unique system of counterpoises, so as to prevent bending. Convenience of the observer is also remembered, and he is provided with a movable observing platform which automatically keeps him at the eyepiece as the telescope turns. Thus he does not need to interrupt his work frequently to adjust himself.

U. S. Weather Bureau.—With the cooperation of the War, Navy, and Commerce Departments, the Weather Bureau of the U. S. Department of Agriculture, on July 1, 1934, will launch part of its new program for increasing the accuracy of its forecasts, W. R. GREGG, chief, has announced. This new program, among other things, calls for more stations for upper air

soundings by airplanes and for more frequent daily forecasts. The part covering more airplane observations can now be put into effect.

The air-mass method of forecasting, long recognized as an aid to accuracy and to longer forecasts, has never been practicable in the Weather Bureau's daily routine because of the difficulty of getting the needed upper-air observations. Facilities offered by Army and Navy pilots at more than a dozen selected stations, at six specially-equipped Weather Bureau airway stations, and at one cooperative station at the Massachusetts Institute of Technology, now remove this difficulty. The Department of Commerce will provide for the transmission of the observations from the points where they are taken to the forecasting stations. According to the present plan, observation flights will be confined to one a day, each beginning about half past five (E.S.T.) in the morning and reaching a maximum height of 17,000 feet above sea level. These flights will be made by Army and Navy pilots and by commercial aviators hired for the purpose by the Weather Bureau. Meteorologists of the Weather Bureau assigned to the air-observation stations will compute, code, and transmit to forecast stations the information the meteorographs bring down. This information will give forecasters an important supplement to the morning surface observations in drawing the weather maps to be used in making the daily forecasts.

Children's Bureau, U. S. Department of Labor.—The complete, detailed report of the study of maternal deaths in 15 states made by the Children's Bureau at the request and with the cooperation of state medical societies and state boards of health is now in press and will appear at an early date. Interest in this subject has been intensified by discussion of the recently published report of similar study in New York City by the New York Academy of Medicine. The Children's Bureau study was made before that of the New York Academy of Medicine which used the same schedule or questionnaire. In both studies the material was gathered by physicians through personal interviews with those who attended the women who died and in both studies the international list of causes of death was used as the basis of analysis. The most obvious differences between the two studies lie in the area covered: 15 states in the children's Bureau study, 47 per cent of deaths being in urban and 53 per cent in rural areas, whereas the New York City deaths were all urban; the larger number of deaths: 7,400 in the Children's Bureau study and 2,000 in the New York study; and the greater detail of analysis in the Children's Bureau study.

Personal Items

Dr. Ales Hrdlicka, of the U. S. National Museum, is again spending the summer in archaeological work among the Alaskan islands. He has with him a group of student volunteers.

Dr. F. A. Wolff, chief of the telephone standards section, National Bureau of Standards, has been designated as a member of the Committee of Departmental Representatives appointed at the instance of Admiral Peoples, Director of the Procurement Division, to determine the cost of the Government's communication services, including telephone, telegraph, and radio.

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Vol. 24 July 15, 1934 No. 7

MATHEMATICS.—*Spinors.*[1] Oswald Veblen, The Institute for Advanced Study, Princeton.

The theory of spinors had its origin in the search for a suitable mathematical tool to use in the extension of the quantum theory to the field of relativity. The quantum mechanics in the form that was given to it by Schroedinger describes the motion of a particle by means of the concept of a wave. It is not, as people used to say, that a physicist thinks of an electron as a particle on Mondays, Wednesdays, and Fridays, and as a wave on Tuesdays, Thursdays and Saturdays, and on Sundays prays for a Messiah who will lead him back to the belief which he held on Mondays. The actual situation is quite different from that. He works with a mathematical theory which he visualizes for some purposes by means of the classical conception of a particle and for other purposes by means of the imagery of the wave theory. The wave that he works with is just a function which satisfies a partial differential equation of a certain type. The physicist believes that by applying a certain integration process to the solution of this partial differential equation he is able to express the probability that the particle which he thinks of shall be in a certain preassigned position with a certain preassigned velocity.

The whole thing is an attempt to find mathematical formulas and language for the discussion of phenomena which did not make sense in terms of the language and formulas which the physicists had been using before. Some people actually go so far as to say that we shall have to make real changes in our habits of thought and use of language. But I am referring to these deep and difficult questions only incidentally. I am concerned with something much more superficial.

[1] This is the fourth of the Joseph Henry Lectures of the Philosophical Society presented March 31, 1934, in honor of the first president of the Philosophical Society. This paper was prepared from stenographic notes taken at the time of the lecture. Received June 2, 1934.

The spinor theory grew out of the attempt to reconcile the wave mechanics with the relativity theory. The wave mechanics was at first developed so as to fit into the framework of the classical dynamics. On the other hand, the theory of relativity has taken such a firm hold of all branches of physics that everyone is convinced that a really sound theory must take it into account. Therefore, the problem was to find a relativistic formulation of the quantum theory.

Also there was experimental evidence indicating that from the partial point of view an electron should not be considered just as a mathematical point but rather as a thing which is capable of a rotary motion, or spin, at the same time that it has a motion of translation. The problem of bringing this concept into the theory of the electron turned out to be closely related to the problem of giving a relativistic formulation to the differential equations of the electron.

What looks like a very good solution of the problem was developed by Dirac, building upon previous work of Pauli and others. Dirac modified the Schroedinger differential equation not only by changing its form but by replacing it by a system of four equations with four unknown wave functions, ψ^1, ψ^2, ψ^3, ψ^4. These four functions were related among themselves in what seemed to be a very intricate manner, but they were evidently the components of a physical quantity of some sort.

When I speak of a physical quantity I am thinking of something which has components analogous to the components of a vector. When you take the three rectangular components of a velocity you recognize that you are taking components of something which has a physical existence. In the same way the quantities which appeared in the Dirac equation were evidently components of some sort of a physical object. But they behaved quite differently from the components of any previously known physical quantity and thus provided a puzzle for the mathematical physicist.

The problem was clearly formulated by the late Professor Ehrenfest. He said, in affect: We are familiar with such things as vectors which are the tools of classical physics. Since the advent of the relativity theory we have got acquainted with the theory of tensors and have been led to believe that any physical phenomena could be described by means of tensors. Now comes a new kind of a physical quantity which is not a tensor and yet has to be taken into account. It has something to do with a spinning electron. Let us call it a *spinor*. Then he called on the mathematicians to provide a theory of spinors, if possible, analogous to the theory of tensors.

The elements of such a theory were in fact already available in Dirac's own work and in the previous work of Darwin and Pauli. The Dirac equation had also been adequately discussed from the point of view of the underlying group theory by Weyl in his book on group theory and quantum mechanics, so that implicitly a good deal of the requisite theory was in existence. Nevertheless, so long as it was possible for a mathematical physicist of the order of magnitude of Ehrenfest to regard it as obscure there remained something of a problem.

Promptly in response to Ehrenfest's challenge, a formal theory of spinors was produced by van der Waerden. This was a theory of two-component spinors which was adequate to the Dirac equation in its original form. But here one has to say, as in so many other cases, that a fully satisfactory account of the subject was possible only after the original theory had been highly generalized. It was in fact so in this case. The original Dirac equation was relevant to the special relativity. The extension to general relativity was indicated first by Weyl and Fock and the system of mathematical equations thus determined has been studied by Schouten, Schroedinger, Einstein and Mayer, and other mathematical physicists. From these studies there has now emerged a clear conception of a class of physical objects which we call spinors and which can be precisely defined.

I shall try to state this definition. In doing so I propose to repeat a number of well-known elementary ideas leading up to the one step which introduces the definition. After this is done the whole matter may seem rather trivial, but it is nevertheless, true that after this foundation is laid the working out of the theory becomes a matter of technical detail.

We start with elementary geometry. How are the points in a room to be described? The first step in such a description is to give names to the points so as to distinguish them, and we agree to use numbers as names. A point will have a first name x, a second name y, and a third name z. The way which we all know for assigning these names is to let x be the distance of the point from the floor, y the distance from the wall at the front of the room, and z the distance from the side wall. That way of assigning the names is of course completely arbitrary. It could be done in some perfectly bizarre way so long as you satisfied the condition of giving different names to different points. A system of naming the points is what we call a coordinate system.

I have mentioned a particular way of naming the points only to emphasize the fact that the particular system we use for assigning these names is of no importance. We can, in fact, when we have one

way of naming them, get any number of other ways by the following device. Suppose you write down these three equations:

$$\begin{aligned} X &= x + y \\ Y &= x - y \\ Z &= z^2. \end{aligned} \tag{1}$$

If we substitute in these equations the numbers x, y, and z appearing in the name of this point, we get three other numbers (X, Y, Z) which gives us a new name for the point, and so we have a new coordinate system. These equations can be solved to give

$$\begin{aligned} x &= \tfrac{1}{2}(X + Y) \\ y &= \tfrac{1}{2}(X - Y) \\ z &= \sqrt{Z}. \end{aligned} \tag{2}$$

If we apply these equations to any point in the room and know the names X, Y, Z, we are able to get back the names x, y, z. We have a dictionary which translates one system of nomenclature for our points into another system of nomenclature. This dictionary is what we call a transformation of coordinates.

In general, a transformation of coordinates

$$(x, y, z) \rightarrow (X, Y, Z)$$

is defined if we replace the right-hand members of equations (1) by quite arbitrary functions subject only to the condition that (1) should be capable of being solved so as to obtain the inverse transformation

$$(X, Y, Z) \rightarrow (x, y, z)$$

analogous to (2). In all this we confine attention to points in the room, that is to say, to a limited portion of space. In practice we require that the functions used shall be amenable to the processes of analysis such as differentiation, etc., corresponding to the technique of the mathematician of the present epoch.

The essential point which I should like to stress in this consideration of coordinate systems and transformations of coordinates is that the coordinate system is something which we ourselves introduce. It is something in addition to the physical state that we are trying to describe and represents our point of view towards the natural phenomena which are under consideration. To be objective, we must somehow or other get away from this thing that we have introduced. In previous generations mathematicians and physicists used to play with the idea of doing without coordinates. The geometry of Euclid is an example in which coordinates were not used and the attempt was

made to reason directly with the physical objects we were talking about. Many will recall the time when it was regarded as important to do vector analysis without coordinates. This idea was based on the feeling that by so doing one was dealing with the natural object itself.

An equally good way of being free from the influence of the coordinates introduced is to use all coordinate systems. Using no coordinate system is, so to speak, the dual idea to using all possible coordinate systems. If you arrange your work in such a way that it applies no matter what the coordinate system is, then you have reached the ideal of dealing with the object itself. This point of view has become very common since the discussions which were brought about by the theory of relativity.

In dealing with physical problems much use is made of vectors. A vector is a special case of what we can call a physical object with components. The idea is something like this: Supposing that in a room we have at every point a tendency of a certain sort, no matter what sort, but a tendency in a definite direction with a definite magnitude. That tendency can be defined by associating with each point (x, y, z) three numbers V^1, V^2, V^3.

$$V^1(x, y, z) \quad V^2(x, y, z) \quad V^3(x, y, z).$$

They describe this tendency and they are the components of something that represents a physical state of affairs. If this physical object is a vector, then on making a transformation into a new coordinate system you will get functions

$$\overline{V^1}(\bar{x}, \bar{y}, \bar{z}) \quad \overline{V^2}(\bar{x}, \bar{y}, \bar{z}) \quad \overline{V^3}(\bar{x}, \bar{y}, \bar{z})$$

of the coordinates $\bar{x}$, $\bar{y}$, $\bar{z}$. When you measure this physical object in the new coordinate system, you will get the new set of quantities $\overline{V}^1$, $\overline{V}^2$, $\overline{V}^3$, and there will be definite formulas which tell you what these components in the new coordinate system are:

$$\overline{V^1} = \mathrm{f}^1(V^1, V^2, V^3) \quad \overline{V^2} = \mathrm{f}^2(V^1, V^2, V^3) \quad \overline{V^3} = \mathrm{f}^3(V^1, V^2, V^3).$$

You will have three formulas of this sort which express the new components as functions of the old ones. There is no need of my mentioning what these formulas are in detail, for in talking about a subject which is full of formulas, we should be hopelessly lost if we got tangled up with particular formulas. The essential point which I want to bring out is that when you change to a new coordinate system you get a new set of components and in every coordinate system there is a set of components for the physical object. If the law which tells you the

new components in terms of the old components is of a particularly simple sort, then your physical object is a vector. There are lots of other physical objects. For example there are physical objects with 9 components that you could call $T_{1\,1}$, $T_{1\,2}$, $T_{1\,3}$, etc., using two indices. Then if you have a certain formula connecting the components in one coordinate system with those in another, the thing you are talking about is a tensor of the second order. The essential things about a tensor are that it is a physical object with components, and that the components are uniquely determined when the coordinate system is given in terms of which the components are described. I am intentionally leaving this statement in a thoroughly abstract form.

When we come to the theory of relativity we must pass from the three-dimensional space of points to the four-dimensional world of events. This is a story which you have probably heard many times. If you want to describe the events which take place in this room, you have to give not merely x, y, and z which tell you *where*, but also t, which tells you *when*, for each event. The essential point is that the events we talk about are things which are capable of being named by means of four names, the four names being numbers. This can be expressed by saying that the events constitute a four-dimensional world or space-time.

Let us transfer what we have just been saying about coordinate systems from the world of points over to the world of events. We make the same remark that we made before. The essential thing about a coordinate system for events is not any particular way of setting up the coordinate system but is the fact that the coordinate system assigns distinct names to different events.

In order to make an objective description of the world of events, we deal with the totality of coordinate systems. We keep free from any particular point of view and so talk about all coordinate systems at once. For this purpose we have a complete theory of transformations of coordinates and a theory of vectors and tensors. A tensor is a physical object such that with every event we are able to associate a set of numbers called its components when we have before us a given coordinate system. If we change to a new coordinate system we get a new set of components of the same physical object.

Thus in the general relativity theory itself we have a set of 16 functions

$$g_{11}(x^1x^2x^3x^4) \quad g_{12}(x^1x^2x^3x^4), \cdots, g_{44}(x^1x^2x^3x^4).$$

These functions of the coordinates are the components of a physical

object called the fundamental gravitational tensor. They satisfy a system of partial differential equations, and the theory of these equations is the relativity theory. The general conception is this: We assume that a given body of physical phenomena is representable by a physical object with components of a certain type, and the theory of these phenomena is contained in the set of differential equations which the components satisfy. This, without any formalism, is the basic mathematical idea which appears in the relativity theory.

Continuing in that theory, it turns out that there are certain other kinds of geometrical objects which have to be considered. The ones which appear first are the electromagnetic potentials. Again there are four components

$$\phi_1, \phi_2, \phi_3, \phi_4$$

which are functions of the coordinates. But, as physicists know, when you give the coordinate system the electromagnetic potentials are not fully determined. You can take another function $f(x^1, x^2, x^3, x^4)$ and add the four derivatives of this function to the components, obtaining

$$\phi_1 + \frac{\delta f}{\delta x^1}, \quad \phi_2 + \frac{\delta f}{\delta x^2}, \quad \phi_3 + \frac{\delta f}{\delta x^3}, \quad \phi_4 + \frac{\delta f}{\delta x^4}$$

without changing the physical significance of these potentials.

Let us try to say what is essential in this without using technical language. It ought to be clear even to those who do not know what these differentiation symbols mean. When we specify a definite coordinate system we have not only one set of four functions which appear as the components of our physical object, but we have a whole class of other sets of components. The physical object in question is of an essentially different kind from those which we have previously been talking about. Its components are not fully determined when the coordinate system is given; something in addition has to be specified before the components are known. This additional something which we have to specify we will call a gauge frame.

I might also try to put it in the following way: We previously said that when we introduce a coordinate system we put something into the phenomena of nature, and before we can be talking about nature itself we have to get free of the coordinate system which we put in. When we talk about electromagnetic potentials, we put something else in, namely, the gauge frame, which has to be specified before we can specify the particular set of components which we are talking about.

So our theory has to be such that we make not only transformations of coordinates but transformations of gauge, and we have to formulate our laws of physical phenomena in a manner which is unaltered not only by changes of coordinate system but also by changes of gauge. Physicists have heard a good deal about that under the heading of gauge invariance. The underlying idea is just as before: In trying to describe nature we have introduced not only coordinate systems, but also another extraneous element called the gauge frame. In addition to the theory of coordinate transformations, there is a theory of gauge transformations which has to be recognized in order to free our theory of physical phenomena from this element which we introduced in our view of nature.

The theory of spinors requires another step in this direction. A spinor is a physical object with components. The number of components is a power of four. In a particular case a spinor may have four components ψ_1, ψ_2, ψ_3, ψ_4. The components are functions of the coordinates just as the ϕ's and g's were, but when the coordinate system and the gauge frame are given, the components of the spinor are not fully determined. You can take a new set of components $\bar{\psi}_1$, $\bar{\psi}_2$, $\bar{\psi}_3$, $\bar{\psi}_4$, which will serve equally well as a set of components of this spinor. The new components are given by means of linear formulas in terms of the old components,

$$\bar{\psi}_1 = T_1^1\psi_1 + T_1^2\psi_2 + T_1^3\psi_3 + T_1^4\psi_4\,;$$

and three other formulas which look like this one. The coefficients T are arbitrary functions. A linear transformation of this sort is called a spin transformation.

When you have given your coordinates and your gauge, there is still something free, which we will call the spin frame, and we are unable to describe our physical object until the spin frame is fixed. In other words, we have got to state everything that we say about a spinor so that it will be true no matter what spin transformation is applied to the components. A spin transformation is very analogous to a coordinate transformation, but it takes place completely independently of the coordinate transformation.

This is the simplest example of a spinor. There are spinors with 16 components or in general with 4_k components and you will have linear formulas which give you the other possible sets of components in the same coordinate system.

I have not yet mentioned one of the important facts about spinors

which give them their significance. Their components are not ordinary numbers. They are complex numbers of the form

$$a + \sqrt{-1}\, b$$

where a and b are real numbers. In this respect they are like other physical objects which appear in quantum theory. There have been cases in physics before where the complex numbers were used as a convenient device, but here they come in an essential way.

The additional degrees of complication which appear in the definition of a spinor correspond to the nature of the physical problem which it is designed to meet. Ordinary vectors and tensors would be well enough adapted to tell where an electron is, in what direction it is going, and what its angular momentum is. But the quantum theoretic problem states the problem differently. It does not ask directly what these quantities are but rather, what are the probabilities that these quantities shall take on preassigned values. To meet this requirement, it is not the components of the spinors themselves which are interpreted in terms of physical measurements, but certain combinations of these components with their complex conjugates. These combinations of components of spinors are components of ordinary tensors and are interpreted as probabilities that the electron will be in a certain place moving in a certain way.

Let us now repeat the description of a spinor in a few words. A spinor is a physical object which has components which are complex functions of the coordinates. The number of components is a power of four. A set of components is fixed only after (1) the coordinate system, (2) the gauge-frame and (3) the spin frame, are fixed. Whenever (1), (2), or (3) are changed, the components are replaced by linear combinations of themselves according to definite rules.

Suppose that you have spinors with 16 components with two indices, X_{AB}, and supposing that these spinors satisfy the condition that

$$X_{AB} = -X_{BA}, \tag{3}$$

so that they are antisymmetric. Then the mathematicians will recognize that connected with them there is a quadratic expression

$$X_{12}X_{34} + X_{13}X_{42} + X_{14}X_{23} = 0. \tag{4}$$

Those spinors which satisfy this relation have peculiar properties, and it is this quadratic relation which puts the spinors into connection with the fundamental tensor of the relativity theory, because the g's

that we have in relativity are also the coefficients of a quadratic expression.

If you are going to describe some particular physical phenomena such as those described by the relativistic theory of the spinning electron, you must pick out one or more particular spinors which embody the physical phenomena in question. It turns out in this special case that you can pick spinors which set up a suitable relationship between the quadratic equation (4) above and the fundamental quadratic form which appears in the relativity theory. The general theory of spinors is the theory of all possible physical quantities of a certain sort. The theory of the electron is the theory of certain particular spinors which describe this electron.

BOTANY.—*New species of* Aulacolepis *and other grasses.*[1] A. S. HITCHCOCK, Bureau of Plant Industry.

The genus *Aulacolepis* was established by Hackel who based it upon *Deyeuxia treutleri* Stapf (*Milium treutleri* Kuntze). It is allied to *Agrostis* and to *Calamagrostis* (Sect. *Deyeuxia*), differing from the former in the comparatively large firm lemma and from most of the species in the prolonged rachilla, and from *Calamagrostis* in the absence of the long callus hairs and the dorsal awn. Hackel described a second species, *A. japonica,* from Japan, and recently a third species, *A. milioides* (Honda) Ohwi, has been described from the same country. *Aniselytron agrostoides* Merr., of the Philippines, described as differing from *Aulacolepis* chiefly in the obsolete or much reduced first glume may also belong to that genus. In the present paper two species are added to this interesting genus, one from Borneo, the other from Tonkin.

Aulacolepis clemensae Hitchc., sp. nov.

Perennis (?); culmi ascendentes, glabri, circa 60 cm. alti; ligula firma, truncata, 1 mm. longa; laminae planae, 8–15 cm. longae, 5–8 mm. latae; panicula laxa, 8–18 cm. longa, ramis ascendentibus, 3–5 cm. longis; glumae inaequales, acuminatae, prima 1-nervia, 2 mm. longa, secunda 3-nervia, 2.5 mm. longa; lemma quam glumae firmius, lanceolatum, scaberulum, 3 mm. longum; processus rachillae tenuis, 0.5 mm. longus.

Apparently perennial; culms ascending, glabrous, several-noded, about 60 cm. tall; sheaths glabrous; ligule firm, truncate, 1 mm. long; blades flat, slightly scaberulous beneath, puberulent on the upper surface, scaberulous on the margins, narrowed toward the base, acuminate, 8 to 15 cm. long, 5 to 8 mm. wide at the middle; panicle rather loose and lax, short exserted or inclosed at base in the uppermost sheath, 8–18 cm. long, the axis angled,

[1] Received April 17, 1934.

nearly glabrous, the branches slender, flexuous, scabrous, somewhat distant, ascending, 3 to 5 cm. long, the branchlets few-flowered; glumes unequal, acuminate, keeled, slightly scaberulous on the keels, the first 1-nerved, 2 mm. long, the second 3-nerved, 2.5 mm. long; lemma lanceolate, compressed, firmer than the glumes, scaberulous over the surface, 5-nerved, the lateral nerves near the margin, the intermediate nerves faint, 3 mm. long, minutely pubescent at base; palea about as long as the lemma but narrower, acuminate, minutely pubescent, inclosed within the lemma, the two keels compressed together; rachilla prolonged between the keels of the palea as a minute bristle 0.5 mm. long.

Type in the U. S. National Herbarium, no. 1,538,647, collected on the boulder margin of the Masilau River, Mount Kinabalu, British North Borneo, alt. about 3000 meters, December 26, 1933, by Mrs. M. S. Clemens (no. 34448).

Aulacolepis petelotii Hitchc., sp. nov.

Perennis (?); culmi caespitosi, erecti, glabri, 25–40 cm. alti; ligula membranacea, 2 mm. longa; laminae erectae, planae, scaberulae, 4–8 cm. longae, 1–3 mm. latae; panicula angusta, laxa, pallida, 6–10 cm. longa; glumae aequales, compressae, 2 mm. longae; lemma circa 2 mm. longum, chartaceo-membranaceum, lanceolatum, 5-nervium, sub apice minute aristatum, callo breviter piloso; rachilla ultra florem in stipitem brevissimum nudum producta; palea angusta, 1.5 mm. longa; stamina 3, antheris 0.5 mm. longis.

Apparently perennial, culms many in a rather loose tuft, erect, or the outer ones somewhat geniculate at base, glabrous, about 3-noded, 25–40 cm. tall; sheaths glabrous; ligule membranaceous, ovate, dentate or somewhat lacerate, about 2 mm. long; blades erect or ascending flat, scaberulous beneath, scaberulous-puberulent on the upper surface, striate-nerved, 4–8 cm. long, 1–3 mm. wide; panicles narrow, loose, pale, whitish or greenish, more or less inclosed in the upper sheaths, 6–10 cm. long, the axis scabrous, the branches scabrous, slender, naked below, branching, the spikelets clustered near the ends of the branchlets, the ultimate pedicels 1 mm. long or less; glumes equal, compressed, narrow, rather abruptly acute, minutely roughened on and near the keel, about 2 mm. long; lemma slightly longer and less compressed than the glumes, chartaceo-membranaceous, lanceolate, 5-nerved, the midnerve projecting just below the tip as a very short awn, the callus short-pilose, the rachilla prolonged behind the palea as a very minute naked bristle; palea narrow about three-fourths as long as the lemma; stamens 3, the anthers 0.5 mm. long.

Type, in the U. S. National Herbarium, no. 1,538,648, collected along a road near Chapu, Tonkin, alt. about 1900 meters, August, 1933, by A. Petelot (no. 4743).

Muhlenbergia lindheimeri Hitchc., sp. nov.

Perennis; culmi erecti, 1–1.5 m. alti, vaginis inferioribus imbricatis compressis; ligula elongata; laminae elongatae, planae, interdum plicatae, 3 mm. latae, scaberulae vel glabrae; panicula angusta, pallida, densiuscula, erecta, 20–40 cm. longa, ramis appressis 2–5 cm. longis; spiculae 2.5–3 mm. longae; glumae aequales, acutae vel obtusiusculae, scabro-puberulentae vel glabriusculae; lemma 2.5–3 mm. longum, glabrum vel obscure pubescens muticum, raro aristatum, arista 1–3 mm. longa.

Perennial; culms erect, 1 to 1.5 meters tall, the numerous overlapping lower sheaths keeled; ligule rather thin, elongate, mostly hidden in the folded base of the blade, blades elongate, firm, flat or usually folded, about 3 mm. wide, scaberulous or glabrous; panicle narrow, pale, somewhat loose, erect, 20 to 40 cm. long, the branches ascending or appressed; spikelets 2.5 to 3 mm. long; glumes equal, acute to rather obtuse, scabrous-puberulent to nearly smooth; lemma usually a little shorter than the glumes, 3-nerved, glabrous or obscurely pubescent, awnless or rarely with an awn 1 to 3 mm. long.

Type in the U. S. National Herbarium, no. 998,949, collected in Texas in 1847 by F. Lindheimer (no. 725).

Other specimens, all from Texas, are: *Berlandier* 1870; *Carter* 19; *Lindheimer* 1255 (Distr. Mo. Bot. Gard.); *E. J. Palmer* 10859, 11004; *Reverchon* 1610; *Silveus* 11, 354, 355; *Tharp* 70, 3076.

This species has been confused with the closely related *M. fournieriana* Hitchc. (*Epicampes berlandieri* Fourn., not *Muhlenbergia berlandieri* Trin.) which is confined to Mexico.

About 1902 there appeared in Queensland, Australia, a species of *Phalaris* which gave promise of being a valuable forage grass. About 1907 it was distributed from the Toowoomba Botanic Gardens, Queensland, and was first grown in the United States at the California Experiment Station and later at other stations. Burbank has distributed the grass as Peruvian winter grass. The species was named by Hackel *Phalaris stenoptera.* It differs from *P. tuberosa* L. only in having a loosely branching rhizomatous base, the lower internodes little or not at all swollen (*P. tuberosa* has a distinctly tuberous base). Agriculturally it seems sufficiently distinct to warrant recognition as a variety.

Phalaris tuberosa var. **stenoptera** (Hack.) Hitchc.

Phalaris stenoptera Hack. Repert. Sp. Nov. Fedde 5: 333. 1908.

Stipa coronata var. **depauperata** (Jones) Hitchc.

Stipa parishii var. *depauperata* Jones, Contr. West. Bot. 14: 11. 1912. Detroit, Utah, *Jones* in 1891.
Stipa parishii Vasey, Bot. Gaz. 7: 33. 1882. San Bernardino Mts., *Parish Bros.* 1079.
Stipa coronata parishii Hitchc. Contr. U. S. Nat. Herb. 24: 227. 1925.

This change is necessary under the International Rules which require that the earliest legitimate name in its own category be retained.

Manisuris altissima (Poir) Hitchc.

Rottboellia altissima Poir. Voy. Barb. 2: 105. 1789.
Rottboellia fasciculata Lam. Tabl. Encycl. 1: 204. 1791.
Hemarthria altissima Stapf & Hubbard, Kew Bull. Misc. Inf. 1934: 109. 1934.

PALEOBOTANY.—*The supposed fossil ear of maize from Cuzco, Peru.*[1] ROLAND W. BROWN, U. S. Geological Survey. (Communicated by JOHN B. REESIDE JR.)

Since 1919 the attention of botanists, interested in the origin and evolution of Indian corn, has from time to time been directed to an object (Fig. 5) described by the late Dr. F. H. Knowlton[2] as a fossil ear of maize. Reference to several papers[3] in which the object is further photographed, described, and compared with varieties of maize, shows that the designation of it as a fossil by Knowlton has at least been tentatively accepted as true. It is my purpose now to produce conclusive evidence that this object is not a fossil, and thus I hope to correct as gently and as far as possible an unfortunate paleontologic mistake.

The known historical facts about this object are meager. It was obtained in 1914 by Dr. W. F. Parks, of St. Louis, Mo., from a curio dealer in Cuzco, Peru. Dr. Parks transmitted it to Dr. Walter Hough, Curator of Ethnology in the U. S. National Museum, who gave it to Dr. Knowlton for identification. Knowlton passed it around among his botanical friends, from one of whom, G. N. Collins, of the U. S. Department of Agriculture, he received the helpful suggestion that externally it had a striking resemblance to a variety of Peruvian maize. Knowlton thereupon described the specimen as a supposed new fossil species of maize, calling it *Zea antiqua*, not because he could distinguish it from the living variety it resembled, but for the sake of independent reference.

That Knowlton unreservedly regarded this object as a fossil is implied in his statement concerning its age. He says: "It is of course extremely unfortunate that nothing is known as to the condition under which this specimen was found. If this were known it might be possible to fix its age with a reasonable degree of certainty. As it stands, however, there is little but *the the fact of its thorough fossilization*[4] to base an opinion on, and from this I venture the tentative suggestion that it seems hardly likely to be younger than at least several

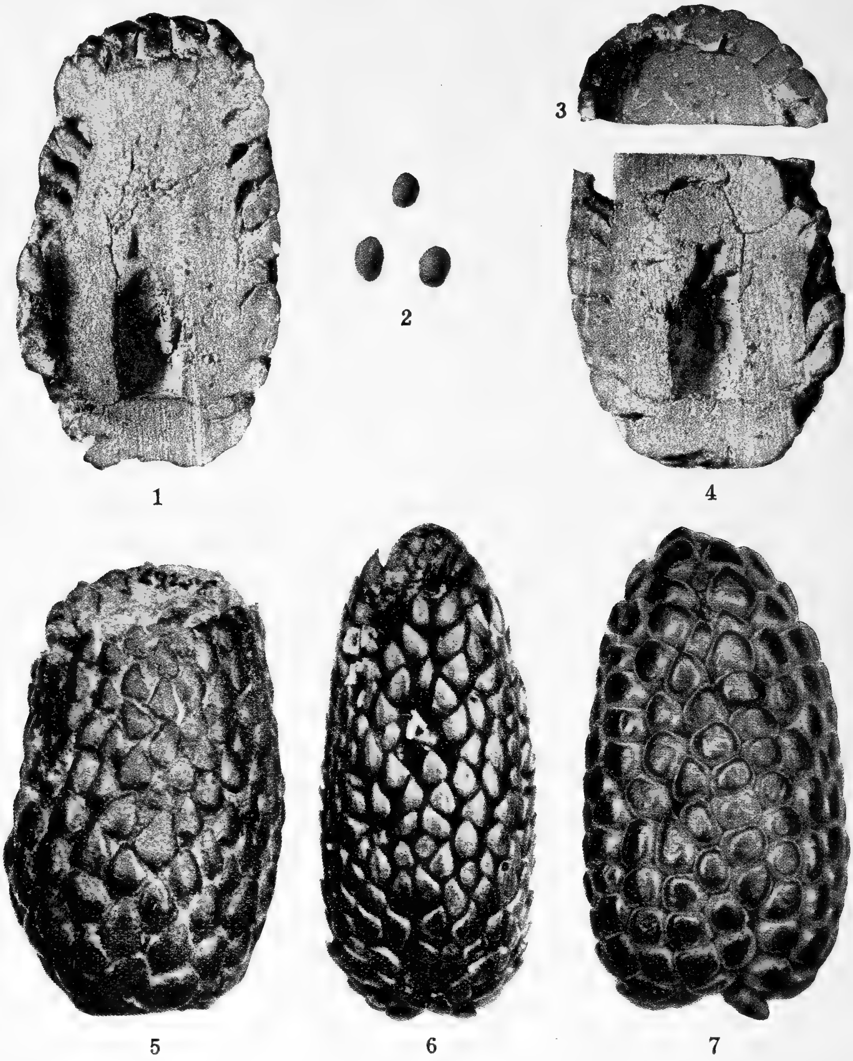
[1] Published by permission of the Director, U. S. Geological Survey. Received Feb. 19, 1934.

[2] KNOWLTON, F. H. *Description of a supposed new fossil species of maize from Peru.* This JOURNAL **9**: 134–136. 1919.

[3] COLLINS, G. N. *A fossil ear of maize.* Jour. Heredity **10**: 170–172. 1919. *An ear of prehistoric maize that resembles the fossil form,* Zea antiqua. Jour. Heredity **14**: 61–64. 1923.

KEMPTON, J. H. *Maize, the plant-breeding achievement of the American Indian.* Smithsonian Sci. Ser., **11**: 319–349. 1931.

[4] Italics mine.



Figs. 1, 4. Lengthwise sections through middle of specimen shown in Fig. 5. Walls of cavity in Fig. 4 show tool marks. Fig. 2. Pellets found in cavity at base of specimen. Fig. 3. Transverse section, a top view of specimen shown in Fig. 4. Fig. 5. The supposed fossil ear of maize before cutting. Fig. 6. Ear of maize from a pre-Inca grave at Arica, on the coast of Chile. Found in 1913. Fig. 7. Ear of maize grown by Peruvian Indians in 1925. All figures natural size. Figures 5, 6, 7, by courtesy of J. H. Kempton, Bureau of Plant Industry, U. S. Department of Agriculture.

thousand years." It is most regrettable that Knowlton did not have the object cut, so that he could determine its petrographic nature. That he did not have it cut seems inexplicable, except on the hypothesis that he considered the specimen as the only one of its kind known and therefore hesitated to damage it by sectioning.

The first fermentation past, this matter aged quietly while the type specimen reposed in the paleobotanical collections of the National Museum. Interest in the supposed fossil, however, was revived recently when Dr. R. F. Griggs, Professor of Botany at George Washington University, and one of his students, F. S. MacNeil, of the U. S. Geological Survey, inquired about it. Suspecting from the time I first saw it in 1929 that this object was not a real fossil, I now determined to test my suspicions by having the specimen sectioned. My assistant, K. J. Murata, cut a transverse section (Fig. 3) near the top, a radial lengthwise section (Figs. 1, 4), and prepared a thin section for microscopic examination. These sections show conclusively that the object, instead of being a fossil, is a very cleverly hand-made, low-fired, clay copy of an ear of Peruvian maize, comparable perhaps to the ears shown in Figures 6 and 7.

Looking at the fresh faces made by the cuts one finds these characters: The color is a dull, dirty brown, tinged with red. The matrix can be scratched easily with a knife. To the naked eye it appears homogeneous, except for scattered light-colored grains of quartz and limestone. On the transverse section the supposed cob showing the insertion of the separate kernels is clearly defined. The cob is roundangular, with a smooth margin between the kernels. This fact would be sufficient in itself to discredit the object as a fossil, for if it were a fossil the surface of the cob would be rough, showing contiguous shallow pits or scars where the kernels were attached. The shape, inner surface, and angle of attachment of these kernels suggest that the kernels were separately fashioned. They are of the same material as the core.

The most striking feature on the radial lengthwise faces is the conical cavity near the base. The walls in the upper portion of the cavity show a few deep, oblique indentations, which are clearly the marks of a blunt-edged tool used in shaping the cavity. Three small, smooth, oval pellets (Fig. 2) that before the sectioning caused a faint rattle when the specimen was shaken, were found in the cavity. The significance of the cavity, the pellets, and the rattle, is as conjectural as that of the specimen itself; but other objects with rattles are said to be not uncommon among the artifacts of Central American and South American Indians.

Knowlton observed the fact that the matrix lacks the delicate cellular structure displayed, for example, by many petrified woods. He, however, did not state his theory as to how the object became fossilized but said that the matrix is "a closely cemented, fine-grained

siliceous sand." Actually, microscopic examination of the thin section by Dr. C. S. Ross, of the U. S. Geological Survey, and Miss Anna Shepard, of the Laboratory of Anthropology, Santa Fe, N. Mex., showed that the matrix is a partially baked clay containing a small amount of coarse-grained material. The latter includes free quartz grains, a little feldspar, hornblende, mica, garnet, and zircon, a considerable amount of fine-grained, iron-stained sandstone, limestone, and calcite, and a few fragments of what apparently are reworked bits of clay previously used for pottery. The object was baked at only a moderate temperature, as is demonstrated by the fact that, although the clay has lost its plasticity, the carbon dioxide has not been driven from the limestone and calcite.

I had hoped that a minute examination of this object would show the personal signature of its maker, but I am not convinced that the obscure and delicate striations present in a few spots actually are baked fingerprints. Nevertheless, the object is so clever a copy of an original ear of Peruvian maize that the maker must be credited with having been an artist of superior skill. The questions as to who made this object and when, where, and why it was made must now be referred to the ethnologists and archeologists. The answers may throw some light on the interesting problems concerning the origin and early cultivation of maize.

This episode of a supposed ear of fossil maize may be closed fittingly with the pointing of a moral, particularly pertinent to paleontologists: Be not deceived by external appearances.

ZOOLOGY.—*Affinities of the Brachyuran fauna of the Gulf of California.*[1] STEVE A. GLASSELL, San Diego Society of Natural History. (Communicated by WALDO L. SCHMITT.)

The author having obtained numerous specimens of Brachyura from the Gulf of California during two collecting trips, and having studied the results of other collectors in that region, believes that a brief summary of the fauna of that region in comparison with that of the regions to the north and south would be of general interest to carcinologists.

The interesting relationship of the Panamian fauna to that of the Gulf of Mexico need not be considered here since this has been discussed by Walter Faxon,[2] but the distribution of tropical (Panamian)

[1] Received December 26, 1933.
[2] Mem. Mus. Comp. Zool. Harvard College, **18**: 231–50. 1895.

Brachyura in the Gulf of California has not been heretofore studied to any extent, and it seems probable that an infusion of southern forms into the Gulf of California has had much to do in making up the character of the rich fauna which is now known to exist in the latter region.

In general it is in the Gulf of California that the tropical species make their most northerly advance on the Pacific coast of North America, although of course some few species have their most northern limits far north of the Gulf. For these northern species it may be difficult to determine whether they originated in northern or southern latitudes. Even a study of their Bathymetric zones does not clarify the situation. To cite a single instance. *Pinnixa affinis* Rathbun was dredged in the Bay of Panama by the *Albatross* in 26 fathoms, March 30, 1888. On October 20, 1933, a specimen was dredged off Newport Bay, California, in 20 fathoms. The inference must be that there is a connecting link between these wide flung stations, that this little crab must be included in the fauna of the Gulf of California, because the Gulf is bracketed between the discovery station and this latest find. Yet to which fauna shall it be allocated? At present this is a matter of personal opinion.

Arbitrary boundaries are taken so as to form a base on which to work. This will exclude some tropical and northern forms from this fauna, which will no doubt be included in the light of future research. I take as the boundaries, for purposes of this paper, those which admit of fewer occasional or accidental intrusions of species into the area bounded by, and including the waters impounded to the north of a line drawn from Cabo San Lucas, in Lower California, to the Port of Mazatlan, in the State of Sinaloa, Mexico, and also the fauna reported and found on the West Coast of Lower California, at Magdalena Bay. In this delimitation of range no attempt is being made to establish or admit of faunal barriers.

Also we will only consider species of Brachyuran Crustacea of the three major groups, namely, the Cancroid or Cyclometopous crabs, the Grapsoid or Catometopous crabs, and the Spider crabs or Oxyrhyncha. The total number of species of the three groups, found within these boundaries is 197, a very large list when we consider that we are dealing with just a part of the marine decapods. For example Dr. Waldo L. Schmitt[3] lists only 181 marine decapods as known to occur within the 100 fathom line off the coast of California.

[3] The Marine Decapod Crustacea of California. Univ. of Calif., vol. **23**: 281. 1921.

A summary of the total number of species of the three groups is as follows:

Cancroid crabs reported in the Gulf of California,	77 species.
Grapsoid " " " " " " "	54 "
Spider " " " " " " "	66 "
Total of all species reported	197

The intrusion of Panamian species into the Gulf of California, number 96 or 48 per cent of all the species reported in these writers. They are divided as follows:

Cancroid crabs	39 species, or 50+ per cent
Grapsoid "	25 " " 46+ " "
Spider "	32 " " 48+ " "
Total of three groups	96 species, or 48+ per cent

The above percentages represent the percent which the Panamian species bear to the total number of species in each family group. Further intensive study and collecting will no doubt show that the Anomuran tribe and the remaining families of the Brachyuran tribe will bear a like relationship to the Panamian fauna.

Another interesting summation is a table showing the number and percentages of species that are indigenous to the Gulf of California.

Cancroid crabs	27 species, or 35+ per cent
Grapsoid "	22 " " 41+ " "
Spider "	26 " " 39+ " "
Total of three groups	75 species, or 40−per cent of all

Then the insignificant influence that northern species play in the Gulf of California fauna, may be visualized by a glance at the following table.

Northern intrusion of species in the Gulf of California.

Cancroid crabs, northern species	11 or 14+ per cent
Grapsoid " " "	5 " 9+ " "
Spider " " "	8 " 12+ " "
Total of three groups	24 or 12+ per cent of all

A recapitulation of the foregoing tables, based on a total for the three groups of 195 definitely allocated species, (two of the 197 species are doubtful in this locality), is as follows:

Panamian species in the Gulf, total 96 species, or 48+ per cent

Indigenous species in the Gulf, total	75 species, or	40− per cent
Northern " " " " "	24 " "	12+ " "

There have been three expeditions in the Gulf of California which have added materially to our knowledge of the fauna of that region. They were, the two *Albatross* expeditions of 1891 and 1911, and the expedition of the California Academy of Sciences in 1921. As before stated it was my good fortune to collect in this territory during part of the years 1931–32–33. A partial summary of the results of this collecting, confined to the three before mentioned groups is:

Cancroid crabs, total of species....	47 or 61+	per cent of species
Grapsoid " " " " ...	32 " 60+	" " " "
Spider " " " " ...	33 " 50+	" " " "
Total of species taken	112 or 56+	per cent

Many new locality records were obtained, extending the range of some species more than 25° of Latitude to the north. In the list of species to follow no extension of range is indicated if the distance is less than 100 miles, nor is extension of range given to that species unless specimens were collected at new localities. In all 46 new locality records are recorded, 18 of these are introductions to the fauna of the Gulf.

As a great deal of the information in this paper is of necessity a compilation, I wish to express my deep appreciation to Dr. Mary J. Rathbun of the United States National Museum, not only for her monographs but also for her personal attention to my efforts.

To facilitate reference to the list of species reported from the Gulf of California, these symbols are used after the name of the author of the species.

A Indicates Panamian species
B " Northern species, those found on west coast of North America, north of Magdalena Bay, Lower California.
C " Indigenous species
D " Apparently indigenous species extending their range a short way either north or south of Cape St. Lucas.
E " Species collected by the author.
F " New locality records of this collection.
(?) " *Tentative identification*

Spider Crabs

MAJIDAE

Stenorynchus debilis (Smith) A E
Podochela vestita (Stimpson) C E
Podochela hemphillii (Lockington) B E
Podochela latimanus (Rathbun) C E
Inachoides laevis Stimpson A E F
Erileptus spinosus Rathbun B E F

Eucinetops lucasii Stimpson C
Eucinetops rubella Rathbun C E
Eucinetops panamensis Rathbun A E
Euprognatha bifida Rathbun B E
Collodes granosus Stimpson C
Collodes tenuirostris Rathbun C D
Collodes tumidus Rathbun C D
Batrachonotus nicholsi Rathbun C D
Pyromaia tuberculata (Lockington) A B E
Dasygyius depressus (Bell) A E
Acanthonyx petiverii Milne Edwards A E
Epialtus sulcirostris Stimpson C D
Epialtus minimus Lockington C E
Eupleurodon trifurcatus Stimpson C
Taliepus nuttallii (Randall) B
Pugettia venetiae Rathbun B
Mimulus foliatus Stimpson B
Leucippa pentagona Milne Edwards A
Sphenocarcinus agassizi Rathbun A
Pelia tumida (Lockington) B C
Notolopas lamellatus Stimpson A E F
Herbstia camptacantha (Stimpson) C D
Herbstia parvifrons (Randall) B E
Herbstia tumida (Stimpson) C D
Libinia setosa Lockington C E
Libinia mexicana Rathbun C E
Lissa aurivilliusi Rathbun A
Lissa tuberosa Rathbun C
Hemus analogus Rathbun C E
Thoe sulcata Stimpson C D E
Pitho picteti (Saussure) A E
Pitho sexdentata Bell A E
Anoptychus cornutus Stimpson A E
Mithrax (Mithrax) spinipes Bell A E
Mithrax (Mithrax) orcutti Rathbun A
Mithrax (Mithrax) armatus Saussure C
Mithrax (Mithrax) tuberculatus Stimpson A
Mithrax (Mithrax) sinensis Rathbun C
Mithrax (Mithrax) sonorensis Rathbun C E
Mithrax (Mithraculus) denticulatus Bell A E
Mithrax (Mithraculus) areolatus (Lockington) A B
Teleophrys cristulipes Stimpson A
Stenocionops contigua Rathbun C E
Stenocionops macdonaldi (Rathbun) A
Stenocionops triangulata (Rathbun) A
Macrocoeloma heptacanthum (Bell) A
Macrocoeloma villosum (Bell) A
Microphrys platysoma (Stimpson) A E
Microphrys branchialis Rathbun C D E
Microphrys triangulatus (Lockington) A E

PARENTHOPIDAE

Parenthope (Parthenope) hyponca (Stimpson) A
Parthenope (Platylambrus) exilipes (Rathbun) A
Parthenope (Pseudolambrus) triangulata (Stimpson) C
Thyrolambrus erosus Rathbun C
Leiolambrus punctatissimus (Owen) A
Tyche lamellifrons Bell A E
Mesorhoea bellii (A. Milne Edwards) A E
Aethra scruposa scutata Smith A E
Cryptopodia hassleri Rathbun C E
Heterocrypta macrobrachia Stimpson A E F

Cancroid Crabs

PORTUNIDAE

Portunus (Portunus) xantusii (Stimpson) B E
Portunus (Portunus) asper (A. Milne Edwards) A
Portunus (Portunus) panamensis (Stimpson) A
Portunus (Achelous) brevimanus (Faxon) A
Portunus (Achelous) minimus Rathbun C E
Portunus (Achelous) pichilinquei Rathbun C E
Portunus (Achelous) affinis (Faxon) A
Portunus (Achelous) tuberculatus (Stimpson) A
Portunus (Portunus) iridescens (Rathbun) C
Callinectes bellicosus Stimpson C D E
Callinectes ochoterenai Contreras C
Callinectes arcuatus Ordway A E
Callinectes toxotes Ordway A
Arenaeus mexicanus (Gerstaecker) A E
Cronius ruber (Lamarck) A E
Euphylax robustus A. Milne Edwards C

ATELECYCLIDAE

Pliosoma parvifrons Stimpson C

CANCRIDAE

Cancer amphioetus Rathbun B
Cancer anthonyi Rathbun B
Cancer gracilis Dana B

XANTHIDAE

Carpilodes cinctimanus (White) A E F
Platypodia rotundata (Stimpson) A E F
Actea sulcata Stimpson A E F
Glyptoxanthus meandricus (Lockington) C E F
Daira americana Stimpson A E F
Lipaestheius leeanus Rathbun A E
Medaeus lobipes Rathbun A
Medaeus spinulifer (Rathbun) A
Cycloxanthops vittatus (Stimpson) A
Cycloxanthops novemdentatus (Lockington) B E F
Leptodius occidentalis (Stimpson) A E
Xanthodius sternberghi Stimpson A
Xanthodius hebes Stimpson C E F
Xanthodius stimpsoni (A. Milne Edwards) A E F
Lophoxanthus lamellipes (Stimpson) A E F
Metopocarcinus truncatus Stimpson A
Lophopanopeus heathii Rathbun B
Lophopanopeus frontalis (Rathbun) B E F
Lophopanopeus lockingtoni Rathbun B E
Lophopanopeus maculatus Rathbun C E
Panopeus purpureus Lockington A
Panopeus chilensis Milne Edwards and Lucas A
Panopeus bermudensis Benedict and Rathbun A E F
Panopeus diversus Rathbun C E
Neopanope peterseni Glassell C E
Hexapanopeus orcutti Rathbun O E F
Hexapanopeus sinaloensis Rathbun C E F
Hexapanopeus rubicundus Rathbun C E
Eurypanopeus ovatus (Benedict & Rathbun) C E F
Eurypanopeus planus (Smith) A
Eurypanopeus planissimus (Stimpson) C E F
Eurypanopeus confragosus Rathbun C E
Eurytium affine (Streets & Kingsley) C E
Eurytium albidigitum Rathbun C E
Micropanope latimanus Stimpson B
Micropanope xantusii (Stimpson) A E F
Micropanope polita Rathbun A E
Micropanope areolata Rathbun B E
Paraxanthias insculptus (Stimpson) A
Pilumnus xantusii Stimpson C
Pilumnus spinohirsutus (Lockington) B E
Pilumnus townsendi Rathbun C E
Pilumnus conzalensis Rathbun C E
Pilumnus depressus Stimpson C
Pilumnus pygmaeus Boone A E F (?)
Pilumnus limosus Smith A E F
Pilumnus stimpsoni Miers C
Pilumnus tectus Rathbun C E
Heteractaea lunata (Milne Edwards & Lucas) A E F
Acidops fimbriatus Stimpson A E F
Ozius verreauxii Saussure A
Ozius perlatus Stimpson A E
Ozius agassizii A. Milne Edwards A E F
Eriphia squamata Stimpson A E F
Quadrella nitida Smith A
Trapezia digitalis Latreille A

Grapsoid Crabs

GONEPLACIDAE

Trizocarcinus dentatus (Rathbun) C
Euryplax polita Smith A E F
Speocarcinus granulimanus Rathbun C E
Speocarcinus californiensis (Lockington) B E F
Oediplax granulata Rathbun C
Glyptoplax pugnax Smith A E F
Chasmocarcinus latipes Rathbun C

PINNOTHERIDAE

Pinnotheres angelicus Lockington C E F
Pinnotheres lithodomi Smith A E F
Pinnotheres muliniarum Rathbun C
Pinnotheres concharum (Rathbun) B E F
Pinnotheres pubescens (Holmes) C E
Pinnotheres margarita Smith A
Pinnotheres reticulatus Rathbun C
Pinnotheres jamesi Rathbun C
Pinnotheres pichilinquei Rathbun C
Fabia granti Glassell C E
Parapinnixa nitida (Lockington) C E F

Dissodactylus nitidus Smith A E F
Pinnixa transversalis (Milne Edwards & Lucas) A E F
Pinnixa tomentosa Lockington B E F
Pinnixa occidentalis Rathbun B
Pinnixa affinis Rathbun A
Tetrias scabripes Rathbun C

CYMOPOLIIDAE

Cymopolia zonata Rathbun C E F
Cymopolia lucasii (Rathbun) C
Cymopolia fragilis Rathbun A

GRAPSIDAE

Grapsus grapsus (Linnaeus) A E F
Geograpsus lividus (Milne Edwards) A E F
Goniopsis pulchra (Lockington) A E
Pachygrapsus crassipes Randall A B E
Pachygrapsus transversus (Gibbes) A E
Planes minutus (Linnaeus) A B E
Planes marinus Rathbun B
Goetice americanus Rathbun C E F
Tetragrapsus jouyi (Rathbun) C E F
Sesarma (Sesarma) sulcatum Smith A E F
Sesarma (Holometopus) magdalenensis Rathbun C E F
Cyclograpsus escondidensis Rathbun C E
Plagusia depressa tuberculata Lamarck A
Percnon gibbesi (Milne Edwards) A E F

GECARCINIDAE

Cardisoma crassum Smith A;
Ucides occidentalis (Ortmann) A
Gecarcinus planatus Stimpson A E

OCYPODIDAE

Ocypode occidentalis Stimpson A E F
Uca monilifera Rathbun C E
Uca princeps (Smith) A
Uca mordax (Smith) A E F
Uca brevifrons (Stimpson) A
Uca macrodactylus (Milne Edwards & Lucas) A
Uca crenulata (Lockington) B D E
Uca coloradensis (Rathbun) C E
Uca musica Rathbun C E F
Uca latimanus (Rathbun) A E

ZOOLOGY.—*The morphology and development of the preparasitic larvae of* Poteriostomum ratzii.[1] JOHN T. LUCKER, Bureau of Animal Industry. (Communicated by BENJAMIN SCHWARTZ.)

INTRODUCTION

The preparasitic larvae of the numerous species of small strongyles (Strongylidae of genera other than *Strongylus*) parasitic in the large intestine of horses have not been described, except in the case of *Triodontophorus tenuicollis*. The literature relating to this group of nematodes contains a number of publications dealing with the structure and development of their free-living larvae, but the available information is without reference to species, with the one exception noted above. The following is a brief summary of the literature pertaining to the preparasitic development of the small strongyles of horses.

In 1866, Baillet (3) published observations on the preparasitic development of *Sclerostoma tetracanthum* Diesing, 1851. As is well

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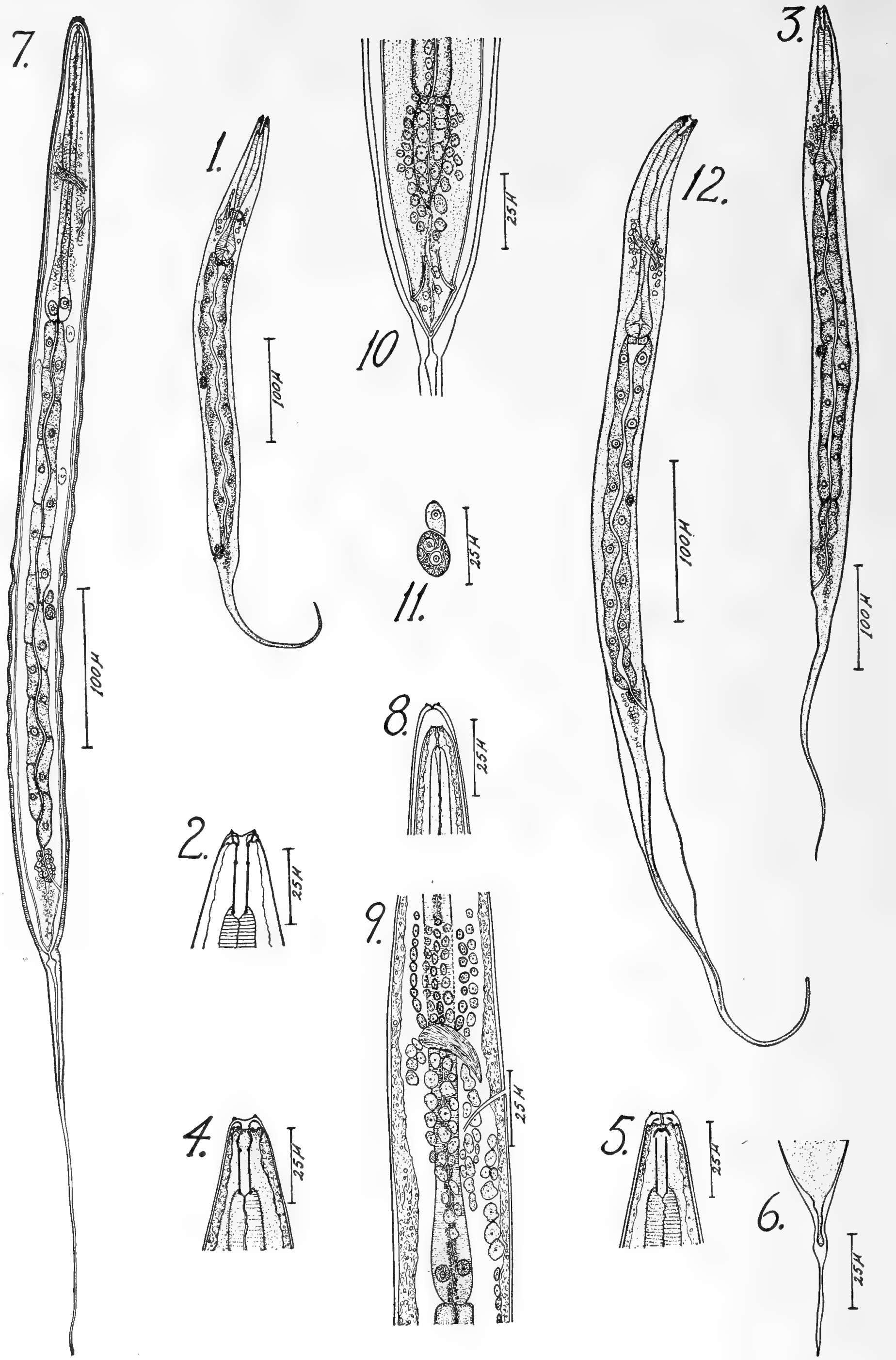
known, *S. tetracanthum* (Synonyms: *Strongylus tetracanthus* Mehlis, 1831; *Cyathostomum tetracanthum* Molin, 1861) was shown by Looss (9) in 1901 to be a composite of at least 13 distinct species. Subsequently the species which comprised the *S. tetracanthum* complex have been found to represent several distinct genera. Giles (6), Albrecht (1), Theiler (15), De Blieck (4), De Blieck and Baudet (5) and Poluszynski (11) have reported investigations on the preparasitic development of specifically unidentified cylicostomes. The morphological data in the above papers are incomplete; even Ortlepp's (10) description of the infective larva of *Triodontophorus tenuicollis* is not as detailed as is necessary for the differential diagnosis of the larvae in question. Larval development in the genus *Poteriostomum* apparently has not been previously studied.

The worms from which cultures were made were removed from the colons of two horses at post-mortem examination. Only a few females and one male of the genus *Poteriostomum* were found in the first horse, and three females and one male were recovered from the second horse. The females were washed first in physiological saline solution and subsequently in water. The eggs, removed by dissection of the living worms, were cultured in small glass dishes containing tap water. One culture contained the eggs from two females, and each of 4 cultures contained the eggs taken from a single female. The account of the larval development presented in this paper is based upon data obtained from all 5 cultures. After the eggs had been removed from the female worms each of the latter was fixed separately and cleared later for microscopic examination.

SPECIFIC IDENTITY OF THE ADULT WORMS

All of the female worms, from which eggs were removed for culture, and the two male specimens mentioned above, have been identified by the writer as *Poteriostomum ratzii* Kotlán, 1919, and have been deposited as No. 31026 in the U. S. National Museum Helminthological Collection. In view of the fact that the descriptions and figures relating to this species published by Yorke and Macfie (17), Ihle (7), Theiler (15), Smit (13), Smit and Notosoediro (14) and Wetzel (16) are in disagreement in regard to a number of morphological details, and in no case conform in all respects to the original description given by Kotlán (8), the following brief comments as to certain morphological features of the writer's specimens are in order. There are from 64 to 84 elements in the external leaf crown (Kotlán reported from 60



Figs. 1–12.—*Poteriostomum ratzii*. Preparasitic larval stages.

Fig. 1.—First-stage larva, newly hatched. Fig. 2.—First-stage larva, anterior end. Fig. 3.—Second-stage larva. Fig. 4.—Second-stage larva, anterior end. Fig. 5.—Second-stage larva, anterior end, during late phase of development. Fig. 6.—Late second-stage larva, posterior end. Fig. 7.—Infective (third-stage) larva. Fig. 8.—Third-stage larva, anterior end. External edge of sheath inadvertently omitted. Fig. 9.—Third-stage larva, region of nerve ring. Fig. 10.—Third-stage larva, posterior portion. Fig. 11.—Third-stage larva, genita primordium. Fig. 12.—First-stage larva in first ecdysis.

to 64 elements; Smit noted 44 elements; Wetzel reported from 44 to 46 elements; Ihle counted 98 elements in one specimen). The internal leaf crown contains from 38 to 48 elements (Kotlán reported from 40 to 44 elements; Ihle counted 48 elements in one case; Wetzel reported from 34 to 38 elements; Smit noted 30 elements). The structure of the 4 submedian and 2 lateral papillae corresponds to the descriptions of Ihle and Wetzel and to the figure of Yorke and Macfie. In respect to the shape of the walls of the mouth capsule, the specimens agree closely with the figure of Yorke and Macfie and with the description given by Wetzel. The dorsal ray pattern is similar to that figured by Smit and by Smit and Notosoediro, except that the lateral dorsal rays are even more widely separated from one another than noted by the above mentioned workers.

P. ratzii var. *nanum* of Theiler, which has been redescribed as a sub-species by Popov (12), has been differentiated from *P. ratzii* principally because the postero-lateral rays in the former are without an "accessory" process near their base. A definite small posterior cuticular swelling or process is present on these rays in the males collected by the writer.

DESCRIPTION OF THE EGG, PRE-INFECTIVE AND INFECTIVE LARVAE

Egg

Usually elliptical in shape, but may be slightly narrower at one pole than at the other. Shell thin and transparent. Measurements of a comparatively small number of eggs showed a wide variation in size, namely from 90μ to 125μ in length and from 57μ to 70μ in width. Eggs present in the uterus near the vagina were in the 16- or 32-cell stage. When fully developed the vermiform embryo has the structure of the first-stage larva described below.

First-stage larva

Shape and size.—Fusiform; similar in appearance to rhabditiform larvae of related strongyles, a long filamentous tail comprising about ¼ to ⅓ of the body length (Fig. 1). Newly hatched larvae from 450μ to 470μ long; larvae at time of first molt, 600μ to 620μ long.

Cuticle.—Thin, with very inconspicuous transverse striations.

Alimentary tract.—Mouth opening surrounded by minute papillae, apparently 6 in number. In the rhabditiform buccal cavity, cheilorhabdions and telorhabdions, (Fig. 2) represented by definite refractive cuticular dots; prorhabdions and metarhabdions discernible as short refractive cuticular rods, refractive dots appearing at their junctures. Esophagus rhabditiform; esophageal valve prominent. Esophagus and intestine united by primordium of esophago-intestinal valve; valve consisting of 4 cells and with a short, narrow, straight lumen. Intestinal lumen dilated and sinuous in living

specimens, expanded terminally both anteriorly and posteriorly. In living specimens the intestine dark and granular, consisting apparently of 16 cells. Lumen of rectum narrow, leading to a conspicuous anus. Rectal glands dorsal and subventral to rectum.

Nervous system.—Nerve ring surrounding isthmus of esophagus. Numerous nerve cells situated lateral and ventral to esophagus both anterior and posterior to nerve ring.

Excretory system.—Excretory pore and excretory canal not seen.

Genital primordium.—Primordium minute, oval, transparent, containing 2 germinal cells, situated ventral to and at approximate equator of intestine. In some specimens, genital primordium in close apposition to a smaller, more anterior, oval or spade-shaped cell, presumably the "giant cell" mentioned by Alicata (2) as of significance in sex differentiation in larvae of *Hyostrongylus rubidus.*

The size relationships of 10 first-stage larvae are given below in Table 1.

TABLE 1.—Size Relationships of 10 First-stage Larvae of Poteriostomum

All measurements in microns

Specimen number	1	2	3	4	5	6	7	8	9	10
Length	620	554	535	516	474	456	470	583	576	485
Width in region of esophageal bulb	30	32	35	28	26	25	27	29	27	25
Length of buccal capsule	17	15	16	13	13	12	12	14	14	14
Distance from anterior end to nerve ring	102	98	105	90	80	70	70	94	91	82
Length of esophagus	130	129	140	115	122	112	116	121	132	120
Distance from bulb of esophagus to genital primordium	117	141	109	117	102	105	103	127	119	100
Distance from genital primoridum to anus	165	104	120	121	109	118	110	135	122	118
Length of tail	190	174	169	153	130	104	127	186	189	131

Second-stage larva

Shape and size.—Similar in shape to first-stage larva; 600μ to 850μ long, the latter being the approximate maximum length attained during preparasitic stages (Fig. 3). During early phases of this stage, tail increasing considerably in absolute length and, as a rule, in proportionate length also. During transition to strongyliform third stage, tissue of tail loosening from cuticle and contracting to form a short, round-tipped process (Fig. 6).

Cuticle.—Thick and very prominently striated; great thickening occuring in tail region during the later phases of this stage.

Alimentary tract.—In young larvae of this stage, alimentary canal similar to that of first-stage larva. During transition to strongyliform stage the following changes occur: Prorhabdions of buccal capsule at first curving toward each other anteriorly (Fig. 4), later uniting (Fig. 5) to form an inverted V, other portions of the buccal capsule becoming reduced; esophagus lengthening slightly, losing its rhabditiform character and assuming a strongyliform structure; meanwhile esophageal valve disappearing, and primordium of esophago-intestinal valve becoming syncytial; boundaries of intestinal cells becoming more distinct, posterior 2 cells being set off by a constriction as a pre-rectum. Anus appearing somewhat less conspicuous than in first-stage larva.

Nervous system.—Similar to that of the first-stage larva, but nerve cells more prominent.

Excretory system.—Excretory pore and excretory duct clearly visible anterior and ventral to esophageal bulb and just posterior to nerve ring.

Genital primordium.—Similar to that of first-stage larva, but slightly larger and containing a greater number of epithelial cells.

The size relationships of 7 second-stage larvae are shown below in Table 2.

TABLE 2.—SIZE RELATIONSHIPS OF 7 SECOND-STAGE LARVAE OF P. RATZII
ALL MEASUREMENTS IN MICRONS

Specimen number	1	2	3	4	5	6	7
Length	654	830	640	631	790	629	668
Width in region of esophageal bulb	26	37	27	29	35	27	28
Length of buccal cavity	14	19	16	17	19	14	14
Distance from anterior end to nerve ring	101	110	106	93	82	82	90
Distance from anterior end to excretory pore	112	135	117	117	130	93	100
Length of esophagus	138	145	134	139	141	115	135
Distance from bulb of esophagus to genital primoridum	140	165	143	102	159	112	150
Distance from genital primoridum to anus	138	225	136	145	163	148	169
Length of tail	222	279	211	228	310	240	200

Third-stage larva

Shape and size.—Fusiform; tail short, slightly tapering, rather suddenly constricted near its distal end and terminating in a minute, rounded, thumb-like process. Larva from 443μ to 584μ long in 10 specimens. Average width in esophago-intestinal region, about 29μ.

Cuticle.—Thinner than that of second-stage larva and finely striated.

Sheath.—Very thick, with wide, prominent, transverse striae. Two median longitudinal prominences extending along lateral surfaces of sheath; these probably represent lateral alae; sheath conforming closely to shape of larva, but extending posteriorly from 200μ to 255μ beyond posterior tip of larva as a fine tapering cuticular tube or tail; sheath rather sharply constricted just posterior to region normally occupied by larval tail when larva is fully extended. At point of constriction, walls of sheath greatly thickened (Figs. 7, 10) for a short distance, enclosing a very narrow lumen; walls becoming thinner again immediately posteriorly, the narrow lumen mentioned above being very short and followed by a more expanded lumen becoming increasingly narrow as walls converge posteriorly to form tapering distal portion of sheath's tail.

Alimentary tract.—Oral opening surrounded by papillae and followed by a short, narrow, slightly cuticularized tube or canal leading into a minute oval cavity; this cavity communicating with a vestibule by means of a short canal. Vestibule variable in size, but conforming in optical section to the following general plan of structure: Anterior margin of vestibule formed by an inconspicuosly cuticularized inverted V, apparently a residue of previous stage prorhabdions; lateral walls cuticular, rather strongly refractive, probably the residuum of metarhabdions of previous stage, converging posteriorly to unite with esophageal lumen; greater part of vestibulum surrounded by esophageal tissue (Fig. 8). Esophagus strongyliform; its lumen highly refractive. Frequently 2 prominent nuclei visible within bulb of esophagus,

presumably being nuclei of esophageal glands. Esophagus leading to a 16-celled intestine; boundaries of intestinal cells definite in young third-stage larvae, but becoming indistinct with exhaustion of reserve food material. Lumen of rectum narrow, leading to an inconspicuous anus.

Nervous system.—Nerve ring slightly posterior to equator of esophagus. In fixed and stained specimens the following details of the nervous system were observed (Fig. 9): 6 narrow chains of nerve cells passing anteriorly from nerve ring about one half distance to cephalic end; nerve fibres not traced from this point anteriorly. A small ganglion posterior and dorsal to nerve ring, laterally a large ganglion passing posteriorly along each side of esophagus and extending nearly to bulb. A ventral ganglion of somewhat smaller size also visible. A chain of nerve cells extending posteriorly from retrovesicular ganglion toward 2 large median ganglia in caudal region. Caudal papillae or phasmids (Fig. 10) about 15μ to 18μ from tip of tail, connecting with tubes or canals passing internally and anteriorly from phasmids. The further course of these canals could not be traced owing to the large number of nerve cells present in this region.

Excretory system.—Excretory pore slightly posterior to nerve ring. Excretory canal or duct passing inward and posteriorly from excretory pore to join a transverse excretory duct. A cross section of lumen of transverse duct visible in optical section of living specimen. Walls of transverse duct contracting and expanding at irregular intervals.

Genital primordium.—Gross appearance similar to that of preceding stages, its position being ventral to the fourth and fifth ventral intestinal cells. The two large germinal cells rather centrally located and surrounded by 11 epithelial cells (Fig. 11). In addition to the "giant cell" near genital primordium, 3 similar cells occuring in body cavity anterior to genital primordium.

The size relationships of 10 third-stage larvae are given below in Table 3.

TABLE 3.—Size Relationships of 10 Third-stage Larvae of P. ratzii
All measurements in microns

Specimen number	1	2	3	4	5	6	7	8	9	10
Length of sheath	737	845	649	706	685	743	712	802	718	762
Distance from posterior end of larva to posterior tip of sheath	211	261	206	253	242	232	205	253	211	220
Length of larva	526	584	443	453	443	511	507	549	507	542
Width of larva in region of esophageal bulb	26	31	20	28	29		24	30		26
Width of sheath in region of esophageal bulb	34	35	25	34	35		30	34		34
Distance from anterior end to nerve ring	94		77	91	90	99	96	98	96	108
Distance from anterior end to excretory pore	115		96	110	110	118	115	115	121	120
Length of esophagus	183	180	162	148	158	180	174	173	180	179
Distance from bulb of esophagus to genital primordium	141	183	124	142	112	146	120	134	149	172
Distance from genital primordium to anus	166	179	117	130	142	151	180	205	146	149
Length of tail	36	40	32	30	34	34	34	38	31	42

DEVELOPMENT OF PREPARASITIC LARVAL STAGES

In water cultures at room temperatures (20° to 26° C.), most eggs contained a vermiform embryo 24 hours after the cultures were pre-

pared. Some eggs hatched within 22 hours and nearly all of the eggs hatched within 40 hours. When the first-stage larvae issued from the eggs, a small amount of helminthologically sterile fecal extract was added to the culture medium. In one culture, after 67 hours of incubation, larvae were observed in the act of casting off the first cuticle (Fig. 12). While the first molt was not actually observed, in two other cases a large number of discarded sheaths were found in the culture dishes examined 72 hours after the cultures were started. In these two cultures all larvae were still in the first stage after 48 hours. Third-stage larvae were found in some cases as early as 115 hours after the cultures were prepared. The thick cuticle of the second-stage larva was not cast off, but was retained by the third-stage larva as a sheath.

SUMMARY

The first-stage larva of *P. ratzii* hatches from the egg in from 22 to 40 hours when kept in water cultures at room temperature (20° to 26° C.); the larva is rhabditiform, varies in length from 450μ to 620μ, and is provided with a long filamentous tail.

The first molt was observed after about 67 hours in a water culture to which helminthologically sterile fecal extract had been added shortly after the first-stage larvae issued from the eggs.

The early second-stage larva is similar to larvae of the preceding stage except that its cuticle is thick and prominently striated. Shortly after the first molt, the excretory pore and excretory canal become clearly visible. Second-stage larvae are from 600μ to 850μ long.

As development proceeds, the second-stage larva becomes further differentiated morphologically. Following the formation of a new cuticle and the attainment of the strongyliform structure, the old cuticle loosens from the body and the larva enters the ensheathed third stage. The second cuticle is not cast off.

The third-stage strongyliform larva has a short tail and is from 443μ to 585μ long. The sheath in which the larva is enclosed is from 650μ to 850μ long, and is characterized by great thickening of its walls in the region immediately posterior to that occupied by the tail of the fully extended larva. A minimum of 115 hours was required for the development from the uterine egg to the infective larva.

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ORNITHOLOGY.—*The hawks of the genus* Chondrohierax.[1] HERBERT FRIEDMANN, U. S. National Museum.

The hook-billed kites of the genus *Chondrohierax* have always been a source of much confusion to taxonomists because of their unusual range of variation in color and size and because of their scarcity in collections. Recently while working over these birds, I

[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 21, 1934.

took the opportunity of bringing together by far the most extensive series of specimens ever assembled and am greatly indebted to the following institutions and their staffs for the loan of material: The American Museum of Natural History, New York (Mr. J. T. Zimmer); the Museum of Comparative Zoology, Cambridge (Mr. J. L. Peters); The Academy of Natural Sciences, Philadelphia (Dr. W. Stone and Mr. M. A. Carriker); the Carnegie Museum, Pittsburgh (Mr. W. E. C. Todd); the University of Michigan Museum, Ann Arbor (Dr. J. Van Tyne); and the California Institute of Technology (Mr. A. J. van Rossem). The specimens assembled total 100 in number; in addition to these Dr. Percy R. Lowe has kindly sent me measurements and geographical data concerning 10 specimens in the British Museum.

If we take Peters' Check List of the Birds of the World (vol. 1: 200. 1931) as a statement of current treatment of the genus, we find three species with no races: *uncinatus*, *megarhynchus*, and *wilsonii*. The last one, restricted to Cuba, is easily disposed of. It is readily told by its yellowish upper mandible. The real problems deal with *uncinatus* and *megarhynchus*. On glancing through the literature, we find that no two authorities give the same range for *megarhynchus*, which is said to differ from *uncinatus* only in having a larger bill. This immediately aroused suspicion as to the validity of the race and was the chief reason for gathering together specimens from all parts of the ranges of the two (tropical Mexico to Bolivia and northern Argentina). However, before it was possible to approach the geographic variations in these birds, obviously conspecific and not, as often stated, distinct species, it was necessary to work out their exceedingly complicated and puzzling plumage sequence. The following detailed description of the plumages of *uncinatus* reveals varieties within phases, certainly a most unusual degree of variability. There are only two real steps in the sequence—juvenal and adult, but both are complex.

PLUMAGES OF C. UNCINATUS UNCINATUS

Adult male

a. Gray phase.—Above dark plumbeous, or plumbeous-black, becoming fuscous, or fuscous-black in worn plumage; the occiput with much basal white and the upper tail coverts tipped and banded with white. Sides of face, ear coverts, and chin deep to dark plumbeous; under tail coverts white to ochraceous-buff, uniform, or with traces of grayish bars occasionally distinctly banded with plumbeous. Remainder of under parts deep plumbeous (usually paler than the upperparts) barred with narrow bands of white, buff, or cinnamon-buff, which are variable in width, and are usually nar-

rowly bordered by fuscous or fuscous-black. Axillaries and under wing coverts uniform deep plumbeous, barred with white or buff; primaries banded (about equally) with white and plumbeous-black below, dark plumbeous and plumbeous-black above, the outer webs often uniform plumbeous-black; secondaries uniform dark plumbeous, occasionally with traces of lighter bars below. Tail plumbeous-black to black, white basally, narrowly tipped with white or deep mouse-gray, and crossed by two bands (the anterior one the narrower) of white, or pinkish-buff, shading to deep mouse-gray posteriorly and towards the outer webs, which are often uniform mouse-gray above. Bill black, olive below; iris greenish white; feet orange-yellow, claws black.

Unbarred variety.—Similar to the above description, but lacking entirely or partially the white barring on the under parts.

Cinnamon-barred variety.—Similar to the above description, but with the gray barring of the under parts more or less replaced by cinnamon-brown or russet, and with more or less indication of a cinnamon or ochraceous-tawny nuchal collar.

b. Melanistic phase.—Entire plumage deep fuscous black, with a slight bronze-purple-green gloss; the occiput with much basal white; tail narrowly tipped with white, and crossed by a single broad white band. Bill black above, dirty olive below, tipped with black; cere and eyelids yellowish green; skin in front of eye blue-green, spot above inner angle of eye orange-yellow; iris white; feet gamboge.

Adult female.

a. Brown phase.—Forehead, auriculars, and sometimes the chin deep gull-gray to deep neutral gray, or dark plumbeous; crown and occiput fuscous to fuscous-black, with concealed white bases; a broad, continuous nuchal collar of ochraceous-buff, tawny, or amber-brown occasionally extending to the ear coverts; remainder of upper parts fuscous to fuscous-black, darker anteriorly, often with slightly paler (sometimes russet) edges to the feathers; upper tail coverts tipped and barred with white or pale gray. Entire under parts, including under wing coverts, white, or ochraceous-white (more ochraceous on the under tail coverts,) with broad nearly equal transverse bars of ochraceous-tawny, cinnamon-brown, russet, or amber-brown, narrowly edged with fuscous or fuscous-black (occasionally this edging is absent, and sometimes it widens to spread over almost the entire bar). Outer primaries pale fuscous above, white, or pale mouse-gray below, cream color, or pinkish buff toward the bases of the inner webs, and distantly banded with fuscous, or fuscous-black (the bands being about one half or one third the width of the lighter interspaces); inner primaries chestnut, or russet, shading to creamy or pinkish buff towards the bases of their inner webs, and distantly banded with fuscous; secondaries light fuscous above, gull-gray below, white, or cream color toward the bases of the inner webs, and somewhat indistinctly banded with dark fuscous. Tail fuscous-black, to black, white basally, narrowly tipped with white or paler hair-brown, and crossed by two bands of hair-brown or mouse-gray, shading to white or pinkish buff on the inner webs, especially anteriorly. Bill black, yellowish olive below; lores olive-orange; sides of cere olive-yellow; spot above eye orange; skin in front of eye grass-green; iris white; feet gamboge.

Gray-backed variety.—Like the above, but with the upper parts plumbeous-black to sooty-black, and with a tendency toward loss of the tawny nuchal

collar. Females in this plumage variation are very like the cinnamon-barred variation of the gray phase of the male.

b. Melanistic phase.—Similar to that of the male.

Immature.

No definite immature plumage; there is a gradual, and probably prolonged molt from juvenal to adult, which appears to commence anteriorly, as well as on the underparts, and to end with the tail.

Juvenal (sexes alike).

a. Light phase.—Forehead, crown, and occiput fuscous-black with white bases to the feathers; a broad, white, cream, or pinkish-buff, nuchal collar, continuous with the white under parts; remainder of upper parts fuscous (shading to fuscous-black on the neck) with narrow cinnamon-tawny or russet margins to the feathers; upper tail coverts tipped and barred with white, or pinkish buff. Entire under parts white, or buff, shading to pinkish buff on the thighs and under tail coverts and either uniform, or distantly barred with hair brown, olive-brown, or fuscous (the number and width of these bars varies considerably); outer primaries fuscous above, creamy white towards the bases of the inner webs, and pallid neutral-gray below, barred with fuscous-black; inner primaries with more or less orange-cinnamon to cinnamon-rufous on both webs; secondaries fuscous above, with some white, or buff, on the inner webs, mouse-gray below, and barred with darker fuscous. Tail fuscous-black, basally white, narrowly tipped with white, cream, buff, or pinkish cinnamon, and crossed with three, or four pale bands, which are uniform hair-brown to light fuscous, on the central pair, and irregularly marked with white, cream, buff, or pinkish cinnamon on the remainder.

b. Melanistic phase.—Forehead, crown, and occiput fuscous-black to sooty black; remainder of upper parts fuscous to fuscous-black, the feathers with concealed white bars or spots near their bases; upper tail coverts tipped and widely barred with white. Entire under parts fuscous to fuscous-black, with concealed white bars on the bases of the feathers, the under tail coverts tipped also with white, or buff; wings fuscous-black crossed by three or four paler bars which are white basally, fuscous above, pale neutral gray below distally. Tail fuscous-black to sooty black, white basally, tipped with white, and crossed by two bands of white, shaded, or marked (especially on the distal band) with hair-brown or mouse gray (that is, the tail pattern like that of the non-melanistic adult).

THE HOOK-BILLED KITES OF GRENADA

The specimens of *uncinatus* from the island of Grenada prove to be constantly smaller than those of the South American mainland or from Trinidad and to have certain color differences as indicated below. For this distinct race I propose the name

Chondrohierax uncinatus mirus subsp. nov.

Type: Adult male, American Museum Nat. Hist., 45054, collected on March 26, 1885, at Morne Rouge, Grenada, by J. Grant Wells.

Subspecific characters.

Adult male.—Similar to the cinnamon-barred variety of the gray phase of *C. u. uncinatus*, but smaller, and with nuchal collar well developed, cinnamon-buff to ochraceous-buff, and the barring on the under parts ochrac-

eous-tawny to tawny, with little or no grayish edgings to the bars. Iris pale green; bill and feet (in dried skins) like those of *C. u. uncinatus.*

Adult female.—Similar to the brown phase of *C. u. uncinatus,* but smaller and differing in the following respects: top of head deep fuscous, with little or no indication of gray; nuchal collar, extending to the ear coverts and cheeks, ochraceous-buff to ochraceous-tawny; upper parts fairly widely edged with tawny or cinnamon-rufous; barring on under parts more ochraceous-tawny to tawny, and with little or no indication of brown edgings.

Immature and *Juvenal.*—Not known.

Adult male (one specimen (type)).—Wing 250; tail 165; culmen from base of cere 28.0; tarsus 30.0; middle toe without claw, 25 mm.

Adult female (three specimens—one sexed "male," another not sexed, but undoubtedly female).—Wing 262–266 (264.3); tail 179–183 (181.3); culmen 30.0–30.5 (30.3); tarsus 30.0–36.0 32.3; middle toe without claw 29.0–34.0 (31.0).

Range: The island of Grenada, where resident.

It is said by observers who have worked in Grenada that the birds there never attain the wholly gray phase found in South America, so that it seems that the island form is a case of arrested plumage development with a tendency to hen feathering in the males (the cinnamon bars of the underparts being essentially a female character in these birds). It is noteworthy that in specimens from Trinidad and Venezuela we find suggestions of hen feathering in males (the cinnamon-barred variety of the gray phase described in the account of the plumage sequence of typical *uncinatus*). In Grenada it has apparently become fixed.

Just as we find a tendency towards hen feathering in the males in this species so too we find signs of cock feathering in the hens in some instances. The gray-back phase of the adult female (represented by specimens from Surinam and Venezuela) is apparently to be so considered.

THE HOOK-BILLED KITES OF MEXICO

Examination of a good series of Mexican specimens reveals the fact that at least two subspecies of the hook-billed kite occur in that country. The birds inhabiting Tamaulipas, Jalapa, Guanajuato, and Jalisco are a very distinct race and may be known as

Chondrohierax uncinatus aquilonis subsp. nov.

Type.—Museum of Comparative Zoology 113711, adult male, collected in Tamaulipas, Mexico, April 9, 1900 (ex Worthen coll.).

Subspecific Characters.—Males very much darker, especially on the underparts, than *uncinatus,* blackish plumbeous instead of deep plumbeous, the white ventral bars broader than in topotypical *uncinatus*; females similar to the darker barred brown phase of typical *uncinatus* (the ventral bars russet or amber brown).

Measurements.—5 males—wing 279–300 (290), tail 186–210 (199), culmen from cere 29–33.5 (31.1) mm; 4 females—wing 275-300 (291.5), tail 191–214 (204.5), culmen from cere 30.5–33 (32.3) mm.

Range.—Tamaulipas, Jalapa, Guanajuato, and Jalisco. It is possible that

two very large birds from Guerrero are of this race, but the only male is in the melanistic phase and cannot be identified subspecifically. I consider them, together with Oaxaca, Quintana Roo, Chiapas, and Guatemalan birds as typical *uncinatus*.

THE UNCINATUS-MEGARHYNCHUS PROBLEM

The form *megarhynchus* was described by Des Murs in Castelnau's *Voyages*, volume 1, Oiseaux, 1855, page 9, plate 1, from Sarayacu, somewhere near the eastern part of the Ecuadorean-Peruvian border. The type locality of *uncinatus* is "Vicinity of Rio to the north of Brazil and all of Guiana." If we measure the culmen from the cere in the plate given by Des Murs, we find it to be 39 mm. The bird is, by plumage, a male. Now, if we take our series of adult *uncinatus* and tabulate their dimensions, we find two things, First, an enormous range of variation; second, no correlation between variation and geography.

Adult male (26 specimens): Wing 265–301 (285.8); tail 173–210 (191.1); culmen from cere 27.0–35.5 (31.3), one 42.0; tarsus 32.0–37.0 (35.1); middle toe without claw 28.0–35.0 (31.1).

Adult female (31 specimens): Wing 268–321 (289.4); tail 191–228 (202.8); culmen from cere 28.0–37.0 (31.6), one 43.5; tarsus 31.0–37.0 (33.8); one 28; middle toe, without claw 28.0–34.0 (30.9).

These measurements arranged geographically are presented in the tables on the following page.

At first glance we may see that birds from eastern Brazil (Bahia, within the original, vague type locality of *uncinatus*), from the Amazon, from Mexico (Chiapas, and Guerrero) and from western Ecuador all match the characters of *megarhynchus*. In other words, "*megarhynchus*" occurs here and there throughout the range of *uncinatus;* furthermore, there is no gap in the size variations between small *uncinatus* and large "*megarhynchus*." This continuity of variation and absence of geographical correlation point to but one conclusion: that *megarhynchus* cannot be regarded as a taxonomic entity in any way distinct from *uncinatus*. The problem, however, is not quite as simple as a bald statement of it implies. One specimen from Ambata Oriente, eastern Ecuador, and four from northeastern Peru (Cajamarca to Rio Huallaga) regions from which *uncinatus* has not been recorded, are so very much larger, in bill length, and also to some extent in the greater width of the rectrices that I cannot put them in with the merged *uncinatus-megarhynchus* series. These birds, which are described below, are apparently the climax in size of the whole species, and it appears that the birds from Ecuador, the Andes of Venezuela, eastern Brazil, and southern Mexico, that have appeared in literature as *megarhynchus* are variants of *uncinatus* in the direction of the Ambata-Peruvian birds. This race may be known as

Chondrohierax uncinatus immanis subsp. nov.

Type.—Museum of Comparative Zoology 149835, adult unsexed (female by plumage), collected at Ambata Oriente, on the eastern base of the eastern Andes, Ecuador, by Reinberg.

TABLE 1.—MEASUREMENTS OF 26 MALE SPECIMENS OF CHONDROHIERAX UNCINATUS UNCINATUS

Country	Number of Specimens	Wing	Culmen from Cere
Mexico (Guerrero)	1	301	42
Guatemala	3	281–299 (287.5)	30.0–33.0 (31.2)
Nicaragua	1	290	33.0
Panama	1	299	30.5
Venezuela	5	265–294 (280.4)	29.0–30.5 (29.8)
Surinam	3	272–291 (283.0)	28.5–30.5 (29.7)
Colombia	2	278–292	30.5–34.0
Ecuador	5	274–289 (284.3)	32.5–35.5 (34.3)
Peru	2	286–298	33.0–33.5
Brazil	2	275–285	27.0–29.5
Argentina	1	300	30.0

TABLE 2.—MEASUREMENTS OF 31 FEMALE SPECIMENS OF C. UNCINATUS

Country	Number of Specimens	Wing	Culmen from Cere
Mexico (Guerrero)	2	283–307	30.0–43.5
Guatemala	1	289	29.5
Nicaragua	1	290	32.5
Costa Rica	1	290	30.0
Venezuela	6	272–309 (287.8)	29.0–31.5 (29.9)
Surinam	2	285–289	28.0–30.5
Colombia	10	268–321 (285.0)	28.0–34.5 (31.4)
Ecuador	4	284–303 (290.8)	28.5–38.0 (33.6)
Peru	2	290–305	34.0–34.5
Brazil	2	293–295	30.0–37.0

TABLE 3.—MEASUREMENTS OF 10 SPECIMENS OF C. U. UNCINATUS SUPPLIED BY DR. P. R. LOWE

Locality	Sex	Wing	Tail	Culmen from Cere	Tarsus
Amazon	Unsexed	295	187	38	36
Brazil, Bahia	"	285 (worn)	194	40	37
Venezuela, Merida	"	289	200	31	34
" "	Male	297	205	31	38
Mexico, Chiapas, Tonala	Male	317	210	38	40
" Colotlan	Male	291	205	30	35
" Chiapas, Tonala	Female	308	213	34	36
" "	Female	305	217	36	39
" "	Female	296	205	35	37
" Oaxaca	Female juv.	292	218	36	36

Subspecific Characters.—Distinguished from *uncinatus* by its huge bill and broad rectrices; wing 317, tail 228, culmen from cere 50 mm.

Adult male.—(2 specimens, Shapaja on the Rio Huallaga, and Chaupe, Cajamarca Province): Wing 315, 319; tail 205, 228; culmen from cere 45, 50 mm.

Adult female.—(3 specimens including the type; Ambata Oriente, Ecuador; Chaupe, Cajamarca Province and Rio Jelashte, San Martin, Peru): Wing 306, 314, 317; tail 225, 228, 229; culmen from cere 48, 50, 50 mm.

Range.—Ambata Oriente, Ecuador, to northeastern Peru (Shapaja, Rio Huallaga; Rio Jelashte, San Martin; and Chaupe Cajamarca).

Remarks.—It may seem strange to describe as new a form from a place not far from the type locaity of *megarhynchus* (which is here relegated to the synonymy of *uncinatus*) but, as is shown above, "*megarhynchus*" has no discrete range or dimensional limits outside the variational range of typical *uncinatus.* By describing *immanis, megarhynchus* is caused to assume its correct place as an intermediate between *uncinatus* and *immanis,* as it should be on geographic grounds. The "*megarhynchus*" type of individuals from Mexico, Venezuela, and eastern Brazil, cannot, of course, be said to be intermediates between *uncinatus* and the geographically remote *immanis,* but they are variants in the direction of the latter.

VARIATIONS, TYPE LOCALITY, AND RANGE OF C. U. UNCINATUS

Males in the gray phase vary slightly from north to south in the width of the white ventral bars, the bars becoming narrower on the average in Peru, the Guianas, Brazil, and Argentina, and broader in Central America, but the difference is very slight. Peruvian males (2) are a little darker gray on the underparts than specimens from other South American countries, but again the difference is a faint one.

As stated above, the locality given by Temminck in the original description of this bird is very broad—from Rio de Janeiro to all of the Guianas. This has never been restricted as far as I know; I hereby restrict it to the vicinity of Paramaribo, Surinam.

The range of the nominate form of the hook-billed kite is as follows: marshy and swampy places in the tropical zone from southern Mexico (Guerrero, Oaxaca, Yucatan, and Chiapas) south through Guatemala, Nicaragua, Salvador, Costa Rica and Panama to Colombia, Venezuela, the Guianas, Brazil, western Ecuador, western, central, and southeastern Peru to Bolivia (Santa Cruz de la Sierra), northwestern Argentina (Embarcación and Tucumân), Paraguay (Fort Wheeler) and southeastern Brazil (São Paulo).

KEY TO THE SPECIES AND SUBSPECIES OF CHONDROHIERAX

a. Upper mandible pale yellowish white, inclining to bluish horn at the base; feathers of upper parts with concealed white bars on their bases (Cuba) .... *C. wilsonii*

aa. Upper mandible black; no concealed white bars on the feathers of the upper parts.
- *b*. Size larger; wing 265–301 mm., in males; 268–321 mm. in females.
  - *c*. Bill smaller; culmen from cere less than 45 mm.
    - *d*. Plumage gray or dark gray, barred beneath with gray or dark gray and white.
      - *e*. Ground color of under parts dark blackish plumbeous, white bars wide (about 5 mm.) . . . . *C. u. aquilonis* ad. ♂
      - *ee*. Ground color of under parts paler, deep plumbeous; white bars narrow (1.5–3 mm.) . . . . *C. u. uncinatus* ad. ♂
    - *dd*. Plumage dark brown or blackish brown above, barred beneath with brown on white ground color or almost unbarred white.
      - *e*. Under parts heavily barred . . . . *C. u. uncinatus* ad. ♀ *C. u. aquilonis* ad. ♀
      - *ee*. Under parts nearly unbarred white . . . . *C. u. uncinatus* juv. *C. u. aquilonis* juv.
  - *cc*. Bill very large, culmen 50 mm. . . . . *C. u. immanis* ad. ♀
- *bb*. Size smaller; wing 250 mm., in male; 262–266 mm. In females (Grenada) . . . . *C. u. mirus*.

I am much indebted to Mr. W. W. Bowen for assistance in compiling measurements and in working out the plumages of these birds. Dr. J. Van Tyne and Mr. L. Griscom also aided by sending notes and opinions about plumages and variations.

MALACOLOGY.—*New Philippine land shells of the genus* Obba.[1]

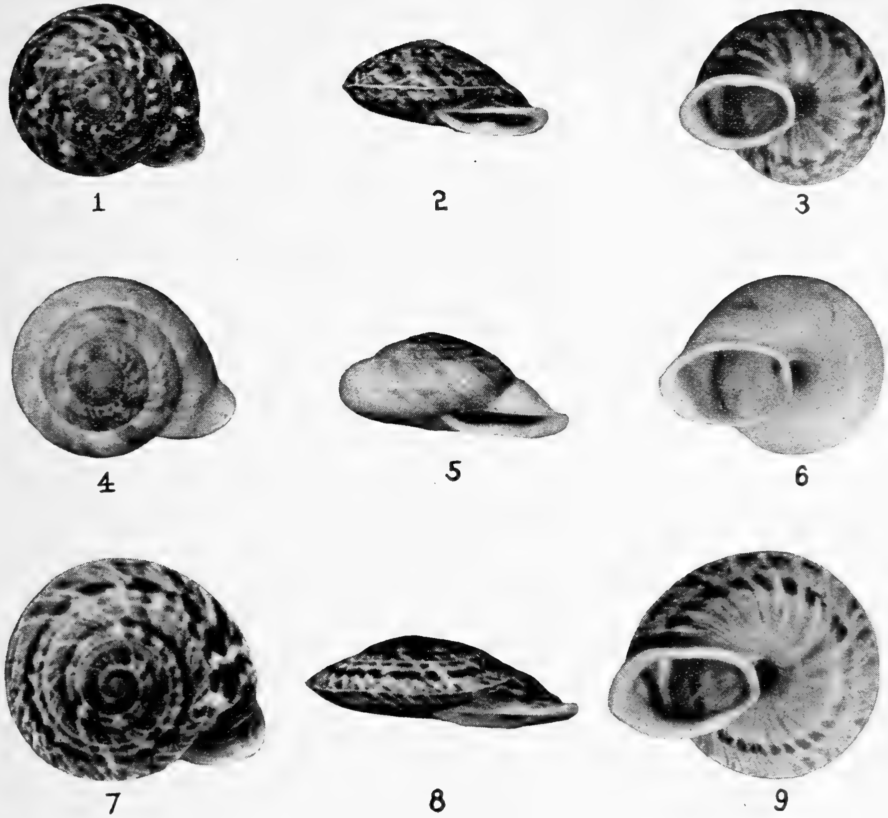
PAUL BARTSCH, U. S. National Museum.

A sending of Obbas to the U. S. National Museum for determination by Mr. Walter F. Webb of Rochester, New York, has brought to light a number of new races, which are here described.

The mass of Philippine material before me belonging to the genus *Obba*, makes it possible to regroup some of the named forms in a more natural arrangement. Mr. Webb's recent sending makes it necessary to give consideration to the mollusks which were described by von Möllendorff (Nachrichtsblatt der Deutschen Malakozoologischen Gesellschaft **20**: 87–88) as

Obbina lasallei Eydoux
Obbina lasallei forma *subcarinata* Mlldff.
Obbina lasallei forma *subcostata* Mlldff.
Obbina lasallei var. *obscura* Mlldff.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received April 6, 1934.



Figs. 1–3.—*Obba listeri cabrasensis.*
Figs. 4–6.—*Obba grandis marivelesensis.*
Figs. 7–9.—*Obba listeri mayae.*

Obbina lasallei var. *grandis* Mlldff.

Also those treated by him in 1898 in the Abhandlungen der Naturforschenden Gesellschaft, Görlitz, **22**: 82–85. Here he renames the shell he described as *Obbina lasallei* above, *Obbina lasallei pallida,* and describes:

Obbina planulata subglobosa Mlldff.
Obbina planulata edentula Mlldff.
Obina planulata subangulata Mlldff.
Obbina planulata depressa Mlldff.

Obba lasallei Eydoux typifies an entirely distinct group of forms whose conspicuous colored banding at once removes them from the present complex, which will have to carry one of the four names be-

stowed by von Möllendorff in 1888. Since von Möllendorff says that the first two named forms were each based upon a single aberrant individual which he found with what he then called *Obbina lasallei* Eydoux at Montalban, Luzon, these are best passed over.

Of the others, that is his var. *obscura* and var. *grandis*, the latter appears more appropriate. I shall therefore here select it for the specific designation of the group.

OBBA GRANDIS Von Möllendorff

The shell ranges from medium size to quite large. Ground color flesh-colored, variously mottled with flecks of dull brown, never actually spirally banded, though a series of spots, which are almost confluent a little posterior to the middle of the turns, suggests a narrow band on the upper surface of the whorls. Base with an obscure interrupted zone of dull brown at some distance anterior to the periphery. The last whorl has the outer lip decidedly deflected at the posterior angle, which gives it a pinched-in effect at this place. Peristome broadly expanded and reflected; basal lip without tooth, or at best with the merest suggestion of a median tumidity.

This species as now conceived ranges over central Luzon where it breaks up into a number of recognizable races or subspecies.

It resembles in size *Obba planulata* (Lamarck), but is less depressed than that species and lacks the strong basal tooth. It also suggests some of the races of *Obba sarcochroa* Möllendorff, but the absence of basal tooth at once distinguishes it from that species. *Obba marmorata* Möllendorff also suggests it, but here, too, we have a strong basal tooth present.

Obba grandis Möllendorff as here constituted embraces:

Obba grandis grandis Mlldff. Montalban (type locality).
Obba grandis grandis forma *subcarinata* Mlldff. Montalban.
Obba grandis grandis forma *subcostata* Mlldff. Montalban.
Obba grandis obscura Mlldff. Balacbac.
Obba grandis depressa Mlldff. Morong.
Obba grandis edentula Mlldff. Morong.
Obba grandis subglobosa Mlldff. Sibul.
Obba grandis subangulata Mlldff. Zambales.
Obba grandis marivelesensis Bartsch. Mariveles.

Obba Grandis Marivelesensis, new subspecies

Figs. 4–6

Shell of medium size, lenticular, with moderately elevated, well rounded spire. Periphery feebly angulated. Base moderately well rounded and moderately openly umbilicated. Ground color flesh colored, with a pale buff tinge. The upper surface, particularly on the early postnuclear whorls, flecked and mottled with pale chestnut brown. On the early turns these flecks tend to form an interrupted median line and a second interrupted, less conspicuous line a little anterior to the summit and a third immediately above the suture, which is even fainter. The base is almost unicolor, the

color scheme being varied slightly by retractively curved, faintly brownish streaks coinciding with the incremental lines in placement. Aperture buff within; peristome white. Nuclear whorls 2, well rounded, the first smooth excepting incremental lines, and the last marked by incremental lines and fine spiral striations. The postnuclear whorls are well rounded and marked by fairly strong incremental lines, spiral striations and the microscopic crisscross sculpture characteristic for the species. The early postnuclear whorls seem to be more conspicuously keeled than those of the adult shell, and the summit of the succeeding turns falls immediately below the keel and is appressed to it. The base is marked by strong incremental lines, fine spiral striations and microscopic, crisscross sculpture. Aperture oval, the outer lip deflected at the posterior angle as if pinched down. There is an impressed line at the junction of the outer and basal lip. The basal lip is provided with a very slight swelling in the middle, suggesting in the merest manner a fold. Parietal wall covered with a thin callus.

Type.—U.S.N.M. No. 314046 was collected by Col. Edgar A. Mearns on the beach at Mariveles, Bataan Province, Luzon. It has 5 whorls, and measures: Height 14.7 mm; greater diameter, 29.8 mm; lesser diameter, 23.1 mm.

	Height	Greater Diameter	Lesser Diameter
Average,	13.8 mm.	28.3 mm.	21.98 mm.
Greatest,	15.2 mm.	30.5 mm.	25.1 mm.
Least,	12.3 mm.	25.3 mm.	19.6 mm.

Obba Listeri Mayae, new species

Figs. 7–9

Shell large, lenticular, acutely keeled at the periphery with a narrow umbilicus; color rather dark, the upper surface marbled, with a heavy row of rather large, elongated spots, which are more or less confluent and form a median band between the summit and the periphery. There is a tendency to the formation of two additional bands; one a little anterior to the summit, and the other a little posterior to the periphery. The rest of the upper surface is variously streaked, blotched and spotted with chestnut-brown of a little lighter color than the median band. The under surface is also marked by an almost uninterrupted broad band of brown, which is about as far anterior to the periphery as the median band on the summit is distant from the periphery. The rest of the base posterior to this band is also mottled, but paler than the dorsal surface, while the reach between the umbilicus and the dark band is wax colored, streaked with darker incremental lines. The aperture is buff; the outer lip shows the dark mearkings within. Nuclear whorls 1¾, well rounded, smooth; postnuclear whorls flattened on the upper surface and slightly up-turned toward the periphery. The succeeding turns are appressed to the narrow edged keel but occasionally this projects slightly beyond the summit of the succeeding turn. The postnuclear whorls are marked by retractively curved, slender, incremental lines and numerous, fine spiral threads which give to the surface a finely reticulated pattern. The fine microscopic, crisscross sculpture characteristic for the group is also represented here. In addition to this, the upper surface is marked, particularly on the later whorls, by strong malleations. The under surface is marked by incremental lines, fine wavy spiral striations, which are a

little stronger at the periphery than toward the umbilicus and the crisscross sculpture referred to above. The last part of the last whorl is conspicuously malleated below the periphery. Aperture oval; outer lip reenforced by a rather thick callus, less strong on the parietal wall, provided with a slight notch at the junction of the basal and upper lip and a fairly strong median basal tooth.

Type.—U.S.N.M. No. 314044 and 10 specimens were collected on Guntang Mountain, Lubang Island. The type has 5 whorls, and measures: Height, 10.6 mm; greater diameter, 35.5 mm; lesser diameter, 28.7 mm.

Ten additional specimens, two of which, U.S.N.M. No. 314045, are in the collection of the U. S. National Museum, and the remainder in Mr. Webb's collection, and the type yield the following measurements:

	Height	Greater Diameter	Lesser Diameter
Average,	12.0 mm.	34.5 mm.	27.5 mm.
Greatest,	13.2 mm.	36.3 mm.	28.9 mm.
Least,	10.6 mm.	32.5 mm.	25.8 mm.

This subspecies suggests in general shape the shell that I collected at Port Tilig, Lubang Island, which I named *O. listeri smithi* in Bulletin 100 of the U. S. National Museum, vol. 6, part 8, page 351. It can, however, be distinguished at once from this by the malleations present on the upper and lower surface, which are absent in *smithi*, and by its much less strong spiral striations.

I have named this *mayae* for Mrs. May Webb, the wife of the donor, at his request.

Obba Listeri Cabrasensis, new subspecies

Figs. 1–3

Shell of moderate size, lenticular, rather high, acutely keeled at the periphery with a rather broad umbilicus. The upper surface is of a deep buff-colored ground color, marbled and vermiculated with spots, splotches and dashes of brown, which are largest on the upper surface in a median line where they partly become confluent to form an interrupted broad band. There is an indication of a second band a little anterior to the summit of much lesser dots, and a third immediately above the periphery, which is even more obscure than the one at the summit. On the under surface there is a broad interrupted band of brown almost as far remote from the periphery as the band on the upper surface is from it. In addition to this, there are incremental streaks of pale brown on the buff background on the under surface. The interior of the aperture is pale buff, showing the brown markings within on the outer lip, while the peristome is faintly buff. Nuclear whorls 1.7; the first smooth and the rest marked by faint incremental lines and microscopic spiral striations. The postnuclear whorls are moderately rounded and marked by retractively curved incremental lines and rather strongly incised spiral striations. There are also malleations, which show best on the later turns on the anterior half of the whorls. In addition to this, the entire surface is marked by the fine crisscross sculpture common to the species. Periphery strongly keeled, the succeeding turns abutting the peripheral keel or sometimes passing slightly under it and allowing it to show

as a feeble thread. The under surface is strongly rounded, marked by incremental lines, the spiral striations equaling those on the spire in strength, and the fine crisscross sculpture. The posterior half also shows feeble malleations. Aperture oval; peristome rather broadly expanded and reflected and joined across the parietal wall by a heavy callus, which renders it complete and provided with a rather conspicuous tooth on the middle of the basal lip. There is also a slight notch at the junction of the basal and outer lip.

Type.—U.S.N.M. No. 314042, was collected on Cabras Island. It has 4.8 whorls, and measures: Height, 12 mm; greater diameter, 26.9 mm; lesser diameter, 21.5 mm. This and 99 additional specimens yield the following measurements:

	Height	Greater Diameter	Lesser Diameter
Average,	11.4 mm.	26.8 mm.	21.68 mm.
Greatest,	13.8 mm.	29.8 mm.	24.3 mm.
Least,	10.1 mm.	23.5 mm.	19.0 mm.

This subspecies recalls *Obba listeri recurvata* Möllendorff from the Island of Lubang, differing from it in its slightly more elevated form, more rounded upper surface, the combination of the two giving the shell a more deeply lenticular aspect. The umbilicus here too is wider.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1059TH MEETING

The 1059th meeting was held in the Cosmos Club Auditorium, Saturday, November 11th, 1933, President O. S. Adams presiding.

The program for the evening consisted of four illustrated reports of expeditions from Washington laboratories that participated in the research program of the recent Polar Year.

The reports were presented by E. W. Eickelberg of the U. S. Coast and Geodetic Survey, J. C. Ballard of the U. S. Weather Bureau, K. L. Sherman of the Department of Terrestrial Magnetism, Carnegie Institute of Washington, and by H. B. Maris of the Naval Research Laboratory.

There was a discussion of the reports participated in by Messrs. Heck, Hazard, Gish, Humphreys and Kracek.

1060TH MEETING

The 1060th meeting was held in the Cosmos Club Auditorium, Saturday, November 25th, 1933, President O. S. Adams presiding.

Program: V. L. Chrisler: *Dependence of sound absorption upon the area and distribution of the absorbent material.*—The results of sound absorption measurements were given showing that when one surface of an enclosure is covered with a highly absorbent material it is impossible to have a diffuse distribution of sound energy. As a result the efficiency of the material is lowered. The results were also given on very much smaller areas showing that under these conditions the material may be more efficient than indicated by measurements on 72 sq. ft.

Discussed by Messrs. Hafstad, Hawkesworth, Stimpson, W. P. White, and Wenner.

R. R. Lukens: *Sound ranging as applied to hydrographic survey.*—The application of sound ranging to hydrographic surveying is an outgrowth of the anti-submarine work of the World War. The first experiments by the Coast and Geodetic Survey were made in 1923 with apparatus built by the Bureau of Standards. The system was first used successfully on the Pacific Coast and the apparatus was soon simplified and improved until it became thoroughly practicable. Briefly, sound ranging is accomplished as follows: Hydrophones are planted at known points near the shore and each is connected to a radio station on shore. When the ship wants a position, a T.N.T. bomb is exploded over the side. The explosion is registered on the chronograph carried on board the vessel and the sound waves travel through the water until picked up by the hydrophones near the shore. When the impulse is received through the hydrophone, the radio transmits an instantaneous signal back to the ship and thus the time of the arrival of the sound at each hydrophone is noted on the chronograph tape. By scaling the tape, the time, to one hundredth of a second, required for the sound to travel from the bomb to each shore station, is ascertained. Knowing the velocity of sound in sea water, the distance from each hydrophone is readily computed, and when the arcs are laid down on the survey sheet, the intersection marks the position of the bomb when it exploded. The subject of velocity of sound in sea water is a big one in itself. Wherever possible the velocity is determined experimentally. This can be done when a shore fix is available as the bomb is exploded. Results so far show a remarkable agreement between the experimental velocities and the theoretical velocities using the bottom temperatures. Experiments for obtaining more knowledge of the path of sound through sea water have just been completed on the Pacific Coast, but as yet no definite conclusions have been reached. Sound ranging is capable of great distance. At one time the ship *Guide* on the Pacific Coast got bombs through at a distance of 216 miles. In the work of the past summer, two vessels on the Pacific Coast frequently used stations 100 miles or more distant with excellent results. Sound ranging, or "radio acoustic ranging" as it is known in the Coast and Geodetic Survey, has resulted in greatly increased accuracy in offshore surveys and also in decreased unit costs due to the fact that work can be carried on at night or in thick weather. (Illustrated by demonstration apparatus.)

Discussed by Messrs. Wenner, Heck, Hersey, Hawkesworth and H. L. Curtis.

The following informal communication was presented.

W. Ramberg.—It was desired in connection with the work on propeller vibrations at the Bureau of Standards to find general solutions of the equation of transverse vibration of a slender beam of variable cross section. In searching the literature for such solutions it appeared that the case of a beam formed by the rotation of the curve $y=Ax^n$, $(0<n<1)$, had been worked out in detail by Prof. Nicholson in 1917 (Proc. Roy. Soc. London A. **93**:506.–1917) in order to find the nodal positions in such beams as a function of the "shape" exponent n. The purpose of Prof. Nicholson's paper was to check a hypothesis of Prof. Dendy according to which the growths at definite distances from the ends of certain sponge spicules proceed from the nodal points; the nodes, he reasoned, were the only points that were sufficiently quiet to allow these growths in the spicules as they vibrated with

their natural periods under agitation by water currents. This conclusion was checked by Prof. Nicholson's mathematical works.

The biologists interest in the morphology of sponges had thus given impetus to a paper which promises to be of value in the analysis of propeller vibrations.

1061ST MEETING

The 1061st meeting, constituting the 63rd annual meeting, was held in the Cosmos Club Auditorium, Saturday evening, December 9, 1933, President O. S. Adams presiding.

The treasurer reported an income from all sources of $1455.43, and expenditures of $1375.63. He also reported an active membership of 304.

The secretaries reported that the following new members were elected during the year: Irvin Naiman, Louis R. Maxwell, James L. Guion, F. W. Sohon, S. J., N. F. Braaten, B. E. Anderson, George F. Strohaver, S. J., Scott E. Forbush, J. B. Wilke, R. S. Cleveland, R. M. Wick, Charles L. Gordon, Charles T. Allen, Norman Bekkedahl, Paul J. Searles, and Albert E. Coldwell. Alfred H. Hodge elected to membership in 1932 qualified in 1933.

The following deaths were reported: Harlan W. Fisk, Frederic A. Young, and John T. Erwin.

The following officers were declared elected for the year 1934: *President*, H. L. Dryden; *Vice-presidents*, O. H. Gish, and N. H. Heck; *Treasurer*, R. E. Gibson; and for the years 1934 and 1935; *Corresponding Secretary*, F. B. Silbsbee; and *Members-at-large of the General Committee*, W. G. Brombacher, J. H. Taylor.

During the year the third Joseph Henry Lecture in memory of the first President of the Philosophical Society was given by K. T. Compton, President of the Massachusetts Institute of Technology.

At the conclusion of the business meeting, E. O. Hulburt presented a paper on *The polarization of light at sea.*—A polarizing prism properly oriented was found to darken the sea relative to the sky, to reduce the brilliance of the sun path and to render the horizon more distinct. In bright weather it increased the visibility of objects against the sea background. Attaching polarizing prisms to a sextant and to binoculars improved these instruments in certain cases. Measurements of the light of the sea ruffled by a breeze from several hundred yards from the observer out to the horizon several miles away showed that the light was often more, and rarely less, than 2/3 polarized with electric rector mainly horizontal but tilted up under certain conditions, e.g., tilted up 30° for the sun bearing 90° and at 45° altitude. From the observations and theory it came out that the sea light was the light of the sky at about 25° to 35° above the horizon reflected by the sea, the reflecting facets of the sea surface being most frequently at about 15° to the horizontal. The width of the sun path calculated from this was in agreement with the observed width of about 6°, 14° and 18° in moderate weather for the sun at altitudes 10°, 20° and 30° respectively. The foregoing results lead to the explanation of a number of breezy sea reflection phenomena such as: (1) A dark bank of clouds rising up over the horizon does not darken the sea appreciably until it reaches an altitude above 25°; (2) One sees practically no reflection of a black or white ship in the water on a breezy day; (3) The fact that the sea is usually bluer, and of course darker, than horizon sky.

Discussed by Messrs. Bittinger, Humphreys, H. L. Curtis, and Hawkesworth.

1062ND MEETING

The 1062nd meeting was held in the Cosmos Club Auditorium, January 6, 1934, President Dryden presiding.

Program: The address of the retiring president, O. S. Adams, entitled *Flatland; not a romance but a necessary expedient.* This address has since been published in full in this JOURNAL, **24**: 201–216. 1934.

F. G. BRICKWEDDE, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

Notes

Helminthological Society.—The Helminthological Society of Washington has initiated the publication of the Proceedings of the Helminthological Society of Washington, Volume 1, No. 1, appearing in March under the editorship of JESSE R. CHRISTIE of the Bureau of Plant Industry. The current number includes the minutes of meetings 157 to 160 together with abstracts of the papers presented at those meetings.

Biological Society.—At the 804th regular and 55th annual meeting of the Biological Society of Washington held on May 5th, 1934, the following officers were elected: *President,* C. E. CHAMBLISS; *Vice-Presidents,* C. W. STILES, H. C. FULLER, T. H. KEARNEY, W. B. BELL; *Recording Secretary,* S. F. BLAKE; *Corresponding Secretary,* JOE S. WADE; *Treasurer,* F. C. LINCOLN; *Members of Council,* W. R. MAXON, A. A. DOOLITTLE, I. N. HOFFMAN, E. P. WALKER, J. E. SHILLINGER.

Personal Items

Detection of incipient weakness of airplane propellers due to fatigue has been facilitated by a new device developed by Drs. HUGH L. DRYDEN and L. B. TUCKERMAN, National Bureau of Standards.

BERTIL RONNMARK, who has been sent to the United States by the Swedish Control Laboratory, Stockholm, to study American governmental methods of drug control, has begun his research in Dr. E. M. NELSON's vitamin laboratory of the Food and Drug Administration. Sweden has recently enacted a new food and drug law patterned to a certain extent after the late Dr. HARVEY W. WILEY's pioneer statute.

CHARLES HENRY KUNSMAN, acting chief of the Fertilizer and Fixed Nitrogen Investigations Division of the Bureau of Chemistry and Soils, has been appointed chief.

CHARLES BITTINGER is completing a group of three mural paintings of scenes from the life of Benjamin Franklin for the Franklin Institute, in Philadelphia. These paintings are visible only by fluorescence produced by ultraviolet irradiation; by common daylight they appear merely as blank white wall panels.

At the spring meeting of the Society of Sigma Xi, the following persons were inducted into membership: Dr. L. H. ADAMS, Geophysical Laboratory of the Carnegie Institution of Washington; Dr. A. G. BOVING, Bureau of Entomology; Dr. D. J. PRICE, Bureau of Chemistry and Soils.

FRANÇOIS E. MATTHES, of the United States Geological Survey, has been appointed "titular member," representing the United States, of the Commission Glaciologique of the International Geodetic and Geophysical Union.

Obituary

JOHN MERTON ALDRICH, associate curator of the Division of Insects, U.S. National Museum, died May 27, at Washington, D.C. Dr. ALDRICH was born in Olmsted County, Minnesota, January 28, 1866. He received the B.S. degree from South Dakota State College in 1891, the M.S. from the University of Kansas in 1893, and the Ph.D. in 1906 from Stanford University. He served as assistant zoologist at South Dakota College 1891–92 and from 1893 until 1913 was associated with the University of Idaho, at first in the capacity of professor of zoology and entomologist of the Experiment Station, later as professor of biology in the University. In 1913 he joined the staff of the Bureau of Entomology of the U. S. Department of Agriculture, being stationed at Lafayette, Indiana, where he continued his work with the Diptera. He came to Washington in 1918 and in 1919 was transferred to the U. S. National Museum as associate curator, in charge of the Division of Insects. Included among his many scientific papers there may be mentioned his *Catalogue of the North American Diptera*, published by the Smithsonian Institution in 1905 and an extensive paper on *Sarcophaga and Allies*. His extensive collection of North American flies containing almost 45,000 specimens was donated to the U. S. National Museum in 1923. In addition to the Washington Academy of Sciences, Dr. ALDRICH was a member of the Entomological Society of America (president, 1921), American Association of Economic Entomologists, Entomological Society of Washington (president, 1926), and Sigma Xi.

EDWARD WILLIAM NELSON, former chief of the Bureau of Biological Survey, died May 19, at Washington, D.C. Dr. NELSON was born at Manchester, New Hampshire, on May 8, 1855. He spent his boyhood on his grandfather's farm in New York, and in Chicago. He was graduated from the Cook County Normal School, Chicago, in 1875. He held the honorary degrees of A.M. (Yale, 1920) and Sc.D. (George Washington University, 1920). He joined the Biological Survey of the U.S. Department of Agriculture in 1890, serving in the field at many points and travelling extensively from Alaska to Mexico. During the years 1907–13 he was chief field naturalist of the Survey; 1913–14, in charge of Biological Investigations; 1914–16, assistant chief and 1916–27, chief of the Bureau of Biological Survey. Following his relinquishment of administrative duties he continued with the Survey for two years, retiring in 1929. His scientific studies continued until his death. From his collections hundreds of new species and varieties of birds and mammals have been described by himself and other workers. His published work includes monographs on various groups of mammals and birds. He was also the author of popular books and articles on various

phases of wild life and wild life conservation. In addition to the Washington Academy of Sciences, Dr. Nelson was a member of the American Association for the Advancement of Science, Washington Biological Society (president, 1912), Society of Mammalogists, and a fellow of the Ornithological Union (president, 1908).

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JOURNAL

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Vol. 24 August 15, 1934 No. 8

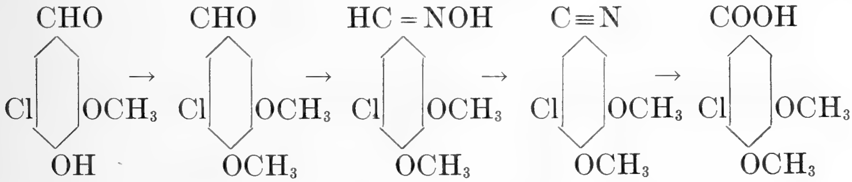
CHEMISTRY.—*The synthesis of 3, 4 dimethoxy-5-chloro benzoic acid.*[1]

Raymond M. Hann, Private Laboratory of J. P. Wetherill, Washington, D. C. (Communicated by R. E. Gibson.)

The complete orientation of the possible mono-chloro derivatives of vanillin by Raiford and Lichty[2] has resulted in the confirmation of Hann's[3] assignment of 3-methoxy-4-hydroxy-5-chloro benzaldehyde as the structure for the chloro vanillin obtained by direct chlorination of vanillin in glacial acetic acid.

This structural foundation now allows the utilization of the halogenated vanillins as starting materials in the synthesis of substituted derivatives of veratric aldehyde of known structure. The aldehydes so obtained may be employed in further synthetic operations to yield a series of oriented compounds of the 3, 4 di-methoxy benzene series.

The present communication reports the preparation of 3, 4 dimethoxy-5-chlorobenzoic acid by the classic series of reactions indicated below.



EXPERIMENTAL

5-Chloro-veratric aldehyde (3, 4 dimethoxy-5-chloro benzaldehyde). This substance was prepared by methylation of 5-chloro vanillin by dimethyl sulfate and sodium hydroxide as previously described.[4]

5-Chloro-veratral-anti-aldoxime. Four and four tenths gms. (1

[1] Received April 6, 1934.
[2] Raiford and Lichty. J. Amer. Chem. Soc. **52**: 4576. 1930.
[3] Hann, R. M. J. Amer. Chem. Soc. **47**: 2000. 1925.
[4] Hann. This Journal, **24**: 125. 1934.

mole) of 5-chloro veratric aldehyde, 1.5 gms. of hydroxylamine hydrochloride (1 mole) and 2.8 gms. of sodium bicarbonate ($1\frac{1}{2}$ moles) were refluxed for 1 hour with 25 cc. 95 per cent ethyl alcohol, 100 cc. of cold water added and the separated solid filtered, washed with water and dried. Yield 4.5 gms.

Recrystallized from 50 per cent ethyl alcohol it was obtained in long slender acicular colorless needles melting at 90° C. (corr.) to a clear colorless oil.

Analysis: 0.1830 gm. consumed 8.53 cc. 0.1 N acid equivalent to 6.52 per cent N. Theory for $C_9H_{10}O_3NCl$ is 6.50 per cent N.

5-Chloro-veratral-anti-aldoxime acetate. Two gms. of the anti-oxime were dissolved in 5 cc. of acetic anhydride and heated to 35° C. for 10 minutes, the solution treated with an excess of 10 per cent Na_2CO_3 solution, and the oil which first separated brought to crystallization by scratching. The washed precipitate was recrystallized from 65 per cent ethyl alcohol, separating in brilliant colorless needles melting at 84° C. (corr.) to a clear colorless oil. Yield quantitative.

Analysis: 0.2099 gm. consumed 8.01 cc. 0.1 N acid equivalent to 5.34 per cent N. Theory for $C_{11}H_{12}O_4NCl$ is 5.44 per cent N.

5-Chloro-veratral aldoxime hydrochloride. One gm. of the anti-oxime was dissolved in 50 cc. dry ethyl ether and a stream of dry hydrochloric acid gas passed into the solution cooled in ice. The hydrochloride precipitated in small colorless needles which were filtered, washed with ether and dried rapidly in an evacuated desiccator over potassium hydroxide. Immediately after drying the compound melted at 117° C. (corr.) but it rapidly underwent decomposition; over-night the melting point dropped to 100° C. (corr.).

Analysis: 0.2257 gm. consumed 8.95 cc. 0.1 N acid equivalent to 5.55 per cent N. Theory for $C_9H_{11}O_3NCl_2$ is 5.56 per cent N.

5-Chloro-veratral-syn-aldoxime. Twenty three and one tenth gms. of the oxime hydrochloride were suspended in 25 cc. of concentrated HCl and 100 cc. H_2O and poured into 500 cc. of ice cold 10 per cent Na_2CO_3 solution, the precipitate, collected, dried and recrystallized from 50 per cent ethyl alcohol. Yield 18.5 gms. The compound crystallizes in colorless needles melting at 112° C. (corr.) to a clear colorless oil.

Analysis: 0.1201 gm. consumed 5.51 cc. 0.1 N acid equivalent to 6.43 per cent N. Theory for $C_9H_{10}O_3NCl$ is 6.50 per cent N.

5-Chloro-veratronitrile (3, 4-dimethoxy-5-chloro-benzonitrile). Ten gms. of the syn-oxime were dissolved in 10 cc. of acetic anhydride and held at 35° C. for 10 minutes, and the anhydride solution poured into

200 cc. of 10 per cent Na_2CO_3. The separated oil rapidly solidified and was recrystallized from 50 per cent ethyl alcohol. Yield 9.0 gms.

After crystallization from 50 per cent alcohol it was obtained in colorless glistening needles melting at 103° C. (corr.) to a clear colorless oil.

Analysis (Parrbomb): 0.2111 gm. gave 0.1540 gm. AgCl equivalent to 18.05 per cent Cl. Theory for $C_9H_8O_2NCl$ is 17.95 per cent Cl.

5-Chloro-veratric acid (3, 4-dimethoxy-5-chloro benzoic acid).—Five gms. of the crude nitrile was boiled for 1 hour with 50 cc. of 20 per cent NaOH. The nitrile formed an oil which disappeared after 10 minutes boiling and ammonia was detected issuing from the condenser. After cooling the acid was precipitated as a white solid by addition of 100 cc. of 1:4 HCl, filtered, washed with H_2O, and recrystallized from 50 per cent ethyl alcohol. The yield was 4.1 gms.

The acid was obtained as soft silky brilliant needles, melting at 191° C. (corr.) to a clear colorless oil.

Analysis: 0.2234 gm. consumed 10.27 cc. 0.1 N NaOH. Theory for $C_9H_9O_4Cl$ is 10.32 cc.

SUMMARY

5-Chloro-veratric aldehyde has been converted to 3, 4-dimethoxy-5-chloro benzoic acid through acetylation of its syn-aldoxime to form the benzonitrile and subsequent alkaline hydrolysis.

Certain other intermediate derivatives in this series of reactions have been isolated and described.

PALEONTOLOGY.—*A new species of* Pecten *from the Oligocene near Duncan Church, Washington County, Florida.*[1] WENDELL C. MANSFIELD, Geological Survey.

Specimens of orbitoid foraminifera from a limestone near Duncan Church, Washington County, Florida, were described recently by Dr. W. Storrs Cole,[2] and were determined to be of the age of the Glendon formation, a middle Oligocene limestone. Cooke and Mossom[3] had previously referred the limestone near Duncan Church to the Eocene.

At the time that Mr. Gerald M. Ponton of the Florida Geological

[1] Published by permission of the Director of the U. S. Geological Survey. Received May 8, 1934.

[2] COLE, W. STORRS. *Oligocene orbitoids from near Duncan Church, Washington County, Florida.* Jour. Paleont. **8**: 21–28, *pls. 3, 4.* 1934.

[3] COOKE, C. W., and MOSSOM, STUART. *Geology of Florida.* Florida Geol. Survey Ann. Rept. **20**: 61. 1929.

Survey collected the orbitoids which were studied by Doctor Cole, Mr. Ponton and the writer obtained several fairly good specimens of a species of *Pecten* from the same limestone. The *Pecten* is believed to represent a new species and is described and figured in this paper under the name, *Pecten duncanensis*. In addition to the *Pecten*, fragments of an echinoid, which may be *Clypeaster rogersi* (Morton), an Oligocene species, were collected.

The *Pecten* corroborates Cole's opinion that the limestone is of Glendon age. The limestone appears to be of the same age as fossiliferous silicified chert exposed on Flint River at Bainbridge, Ga., which has been correlated with the Glendon.

The writer also visited a sink on the A. L. Parish Farm, 3½ miles southeast of Wausau, Washington County, Florida, where 20 feet of limestone is exposed. The limestone is separable into two beds, the lower of which is believed to be of the same age as that of the limestone exposed at Duncan Church. The upper bed carries an abundant fauna which, according to Cooke and Mossom,[4] appears to be of Tampa age. However, this fauna has not been studied sufficiently to determine definitely its relationship to the Tampa fauna.

Pecten (Lyropecten) duncanensis Mansfield, n.sp.

Figures 1, 2, 3

Shell small, rather thin, inequilateral, weakly inflated, the left valve more convex than the right. Right anterior ear with a moderately deep notch and sculptured with five rather strong radials, the innermost of which lies close to the submargin, and with transverse closely-spaced imbrications; right posterior ear with six strong, imbricated radials. Disk of right valve sculptured with 23 to 25 (24 on holotype) squarish, scabrous and imbricated ribs, separated by intervals of about the same width as the ribs. The early portion of each rib is narrowly rounded and the later portion nearly square; the latter is undercut on the sides and is ornamented on the top with three scabrous threads, the medial one of which is the strongest. The interradial spaces on the smaller specimens are either without a radial or, if present, it is only faintly indicated. A fragment of a larger shell (fig. 1, U.S.N.M. No. 373056) shows one interradial thread of moderate strength in each space. Ribs and interspaces crossed by imbrications whose edges are about one millimeter apart. Left valve sculptured similarly to the right, except that the interradial thread appears to be more strongly developed. Submargins low and marked with faint radials.

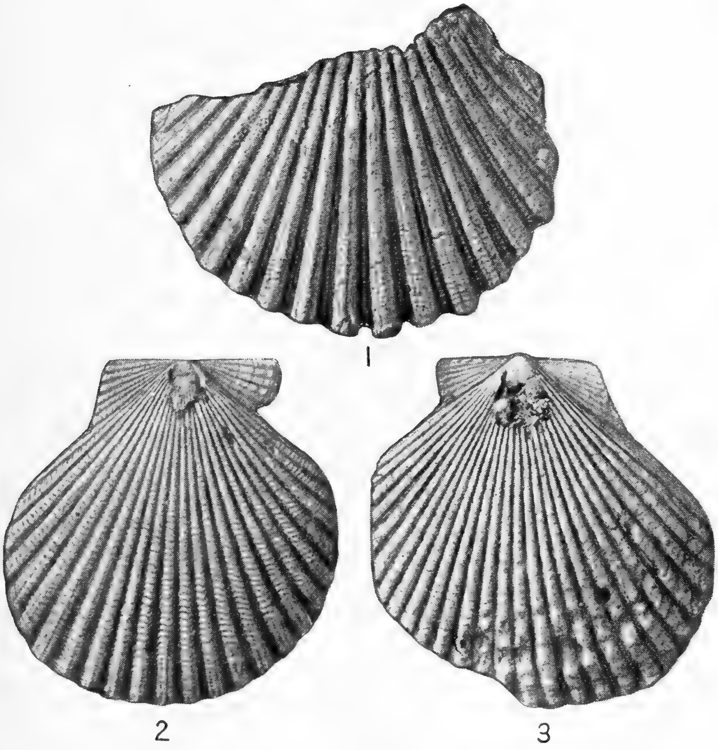
Dimensions of holotype (U.S.N.M. cat. no. 373055): Right valve, length 22.5 mm.; height, 23 mm.; convexity, 4 mm. Paratype (U.S.N.M. cat. no. 373056): Left valve (not entire), length 23+ mm.; height 23+ mm.

Type locality: Station 12724, old quarry near Duncan Church, Washington County, Florida.

Geologic horizon: Oligocene, Glendon formation.

[4] Idem., p. 96.

Pecten duncanensis is closely allied to, if not the same as, specimens figured and incorrectly referred by Dall[5] to *Pecten suwaneënsis* Dall, from the Glendon chert at Bainbridge, Ga. Cooke[6] recognized that the Bainbridge material represented a new species which, however, he did not name. *P. duncanensis* differs from *P. suwaneënsis*, an Eocene Ocala limestone species, in having a higher left valve and squarer ribs which instead of being rounded are ornamented on top with tricarinate radial sculpture. There are four specimens (U.S.N.M. cat. no. 115777) in the U. S. National Museum designated as types of *P. suwaneënsis*. The matrix adhering to these specimens carry foraminifera which have been examined by Mr. Lloyd G. Henbest of the U. S. Geological Survey, who identifies with comparative certainty *Operculina floridensis* Cushman and *O. vaughani* Cushman, both of Ocala, Eocene, age.



Figs. 1–3.—*Pecten* (*Lyropecten*) *duncanensis* Mansfield. Figs. 1, 3.—Paratypes ×2. Fig. 2.—Holotype ×2.

The type of *P. suwaneënsis* does not appear to have been figured.

[5] Dall, W. H. Proc. U. S. Nat. Museum, **51**: 492, *pl. 83, figs. 2, 3, 4.* 1916.
[6] Cooke, C. W. U. S. Geol. Survey Prof. Paper **133**: 5. 1923.

ZOOLOGY.—*The development of the Trichostrongyle,* Nippostrongylus muris, *in rats following ingestion of larvae.*[1] BENJAMIN SCHWARTZ and JOSEPH E. ALICATA, Bureau of Animal Industry.

In the course of investigations on the life history of the dog hookworm, *Ancylostoma caninum,* the view has been advanced by certain investigators that the larvae of this helminth are capable of developing in the intestine of dogs without migration to the lungs. These parasites usually migrate to the lungs when introduced through the mouth into the bodies of small laboratory animals. The direct development of *A. caninum* in dogs was first noted by Yokogawa (7) and was later confirmed by Scott (5). Fuelleborn (2) reported the same findings as a result of experimental infections with another species of dog hookworm, *Uncinaria stenocephala,* and he observed, moreover, that only a small percentage of the larvae of *U. stenocephala* took the roundabout journey to the lungs even in abnormal hosts. While these conclusions are not accepted by all investigators, having been challenged especially by Nakajima (4) and Nagoya (3), the data which have been published in support of what appears to be a rather unorthodox view, seem to be sound and convincing.

During the past few years the writers have been engaged in experimental investigations on the course of infection of rats with *Nippostrongylus muris,* a trichostrongyle nematode of wild rats, readily transmissible to white rats. Several experiments were undertaken with a view to determining whether the migration of the larvae of this species to the lungs is an essential part of the developmental process within the host, or whether the occurrence of the larvae in the lungs is merely the result of the worms being accidentally arrested in the lungs while en route from the skin to the intestine.

Yokogawa (6), who first determined the life history of *N. muris,* noted that white rats could be infected with this worm through the mouth as well as percutaneously; the resultant infestation following the introduction of larvae into the mouth was very slight, and in some cases no infestation could be produced. According to this investigator the infestation resulting from a percutaneous infection was always proportionate to the number of larvae applied to the skin. Africa (1) noted that the intensity of experimental infections of rats by mouth with *N. muris,* as judged by the number of eggs eliminated with the feces of infested animals, was very low as compared to the number of eggs eliminated from percutaneously infected hosts when the rats in both groups were given equal numbers of larvae.

[1] Received May 21, 1934.

While the available evidence indicated that the skin was the more normal portal of entry of *N. muris* into the body of its host, and that the entry of the larvae through the mouth produced but slight infestations or no infestations, no data were available to account for these results. The data obtained by the writers not only have cleared up this point in the life history of *N. muris* but also have a bearing on the question of the biological significance of the migration of the larvae of this species from the intestine to the lungs.

Infective larvae from cultures of rat feces mixed with animal charcoal were introduced into the mouths of 10 rats in a few drops of water with the aid of a small pipette. Rats 1, 5, 9 and 10 received 2,000 larvae each; the remaining rats received 1,000 larvae each. The experimental rats were killed with ether, and were examined post mortem for evidence of worm infestation. The lungs were chopped into small pieces with a pair of fine scissors and put through the Baermann apparatus; this was followed by an examination of each fragment of lung tissue in press preparation. The stomach, small intestine, and large intestine were examined separately with the aid of the Baermann apparatus. Examinations for larvae were also made of the hearts' blood and, in some cases, of scrapings of the intestinal mucosa, as well as of the liver and intestinal lymph glands; the latter two tissues were examined in press preparation and with the Baermann apparatus. In a number of instances the feces of the experimental rats were examined for larvae.

PROTOCOLS

Rat 1 (killed 3 hours after feeding of larvae)—15 infective larvae in small intestine, one of which was obtained by scraping the mucosa; 95 infective larvae in large intestine; some of the larvae from both locations sluggish, giving but a feeble response to tactile stimulation with the dissecting needle; other larvae normally active.

Rat 2 (killed 3 hours after feeding of larvae)—9 infective larvae in stomach; 25 infective larvae in small intestine; 32 infective larvae in large intestine. All larvae alive.

Rat 3 (killed 5 hours after feeding of larvae)—10 live larvae in large intestine.

Rat 4 (killed 18 hours after feeding of larvae)—2 dead larvae in large intestine and 23 dead larvae in feces.

Rat 5 (killed 24 hours after feeding of larvae)—9 live third-stage larvae in lungs.

Rat 6 (killed 30 hours after feeding of larvae)—9 live third-stage larvae in lungs; 1 dead larva in large intestine.

Rat 7 (killed 35 hours after feeding of larvae)—10 live third-stage larvae in lungs; 2 dead larvae in large intestine.

Rat 8 (killed 42 hours after feeding of larvae)—5 live third-stage larvae in lungs.

Rat 9 (killed 48 hours after feeding of larvae)—5 live fourth-stage larvae in small intestine.

Rat 10 (killed 72 hours after feeding of larvae)—2 live larvae in lungs; 44 live fourth-stage larvae in small intestine.

DISCUSSION

It is evident from these data that following the ingestion of infective larvae of *N. muris* by white rats, the worms passed into the stomach, where they were found 3 hours after ingestion. From the stomach the larvae passed into the small intestine in which location some of them became sluggish. Many larvae passed down into the large intestine where they were found still alive 5 hours after ingestion. The larvae died in the large intestine without undergoing any development and passed out with the feces (rat 4). A small number of larvae apparently bored into the wall of the small intestine, as evidenced by the discovery of 1 larva in the scrapings of the intestinal epithelium of rat 1, and subsequently got to the lungs.

In the series of experiments described in this paper, larvae were not found in the lungs from 3 to 18 hours following their ingestion; larvae were recovered from the lungs of experimentally infected rats from 24 to 72 hours after experimental feeding. While larvae, showing no development beyond that of the infective stage, were found in rats 3 hours after feeding, they were absent from the small intestine between 5 and 42 hours after feeding, reappearing again as fourth-stage larvae from 48 to 72 hours after feeding. These observations are in agreement with those of Yokogawa (6) who noted that following percutaneous infection, *Nippostrongylus* larvae appeared in the lungs in from 14 to 20 hours, remained in this location until 50 to 65 hours, and occasionally as late as 72 hours, after having been placed on the skin.

The development and migration of *N. muris* in white rats, following ingestion of infective larvae, followed the same course as observed by Yokogawa (6) subsequent to percutaneous infection. The larvae migrated to the lungs, where they continued their development to the

fourth stage[2] and finally returned to the small intestine. The larvae which failed to penetrate the intestinal mucosa following ingestion, and apparently the vast majority of larvae introduced into the mouth did fail, passed into the large intestine where they died and were subsequently eliminated from the body. No evidence was found of the development of larvae in the intestine without migration to the lungs. Apparently the series of developmental changes in *N. muris* which takes place in the lungs of the host and which culminates in an ecdysis, did not occur as long as the worms remained in the intestine. The migration of the larvae to the lungs appears to be an essential step in the developmental history of these parasites, the worms not being adapted to survival in the small intestine until the completion of the second ecdysis in the lungs; the first ecdysis takes place outside of the host, the larva attaining the infective stage following the first molt, and the final ecdysis takes place in the intestine.

SUMMARY

When introduced into the mouths of white rats, *Nippostrongylus muris* passed into the stomach, some larvae surviving in the stomach for 3 hours, and thence into the small intestine. A relatively small percentage of larvae evidently penetrated the intestinal mucosa and reached the lungs. Other larvae passed into the large intestine where they died and were expelled with the feces.

The larvae which migrated from the intestine to the lungs developed in the normal way; larvae were found in the lungs of white rats from 24 to 72 hours after experimental feeding.

Live larvae showing no development beyond that of the infective stage were found in the intestine of white rats up to 5 hours after experimental feeding; no larvae were found in the small intestine from 18 to 42 hours after experimental feeding, though in three out of four rats involved larvae were present in the lungs during these periods. Two rats killed 48 and 72 hours, respectively, after experimental feeding, contained fourth-stage larvae in the intestine.

The data presented in this paper indicate that the larvae did not develop in the small intestine to the fourth stage, but that the time of the appearance of fourth-stage larvae in the small intestine, coupled with the finding of larvae in the lungs, warrants the conclusion that

[2] According to Yokogawa (6) *N. muris* molts only three times, namely, once as a free-living larva, once in the lungs and once in the intestine. The writers have followed Yokogawa in regarding the development of the larvae in the lungs as involving two stages, one molt being suppressed.

the third-stage larvae developed in the lungs and returned to the intestine as fourth-stage larvae.

The migration of *N. muris* to the lungs appears to be an essential part of their life history, irrespective of their path of entry into the body of the host.

It may be concluded that *N. muris* passes through three distinct developmental phases in the course of its life cycle, namely: (1) The free-living stage, involving one ecdysis, following which the worms emerge as second-stage infective larvae; (2) the pulmonary parasitic stage, in the course of which the larvae develop to the third stage and finally to the fourth stage, the latter stage preceded by an ecdysis; (3) the intestinal parasitic stage in the course of which the larvae grow to the fifth or final stage, preceded by a third ecdysis, followed subsequently by the development of the worms to fertile maturity.

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This paper was read at a meeting of the Third Pan-Pacific Science Congress held in Tokyo in 1926. The date of publication is uncertain.

ZOOLOGY.—Sphaeropomatus miamiensis, *a new genus and species of Serpulid polychaete.*[1] Aaron L. Treadwell. (Communicated by Mary J. Rathbun.)

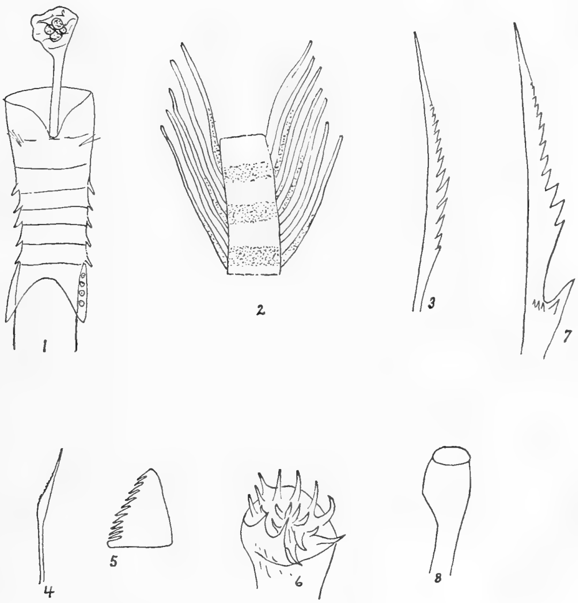
In May 1933, Captain John W. Mills presented to the United States National Museum an unusually large and perfect specimen of the fresh-water shrimp *Macrobrachium jamaicense* from the Miami River,

[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 12, 1934.

Florida, upon the carapace of which were a number of Serpulid worm tubes. These tubes upon examination were found to belong to a new genus and species of annelid which I now name *Sphaeropomatus miamiensis*.

Sphaeropomatus, n. gen.

Peculiar toothed setae borne on the first thoracic somite. Collar prominent, thoracic membrane small. Operculum spherical, supported on a smooth



Figs. 1–5.—*Sphaeropomatus miamiensis*. Fig. 1.—Anterior end of body showing operculum with blood spheres, ×20. A few eggs lie under the thoracic membrane. Fig. 2.—Detail of rachis with filaments, ×68. Fig. 3.—Toothed seta from first somite, ×250. Fig. 4.—Geniculate abdominal seta, ×250. Fig. 5.—Thoracic uncinus, ×600. Fig. 6.—Operculum of *Mercierella enigmatica* after Munro, ×23. Figs. 7, 8. —*Ficopomatus* sp. after Southern. Figs. 7.—Toothed seta from first somite. Fig. 8.—Operculum.

heavy stalk. No spines or other processes on the operculum. Tube calcareous, smooth, cylindrical.

Sphaeropomatus miamiensis, n. sp.

The body of the type is 8 mm. long (including the branchiae), and is never more than 0.5 mm. broad. Branchiae not more than 7 on a side, with heavy rachids (fig. 2), and long, slender filaments, the end of each rachis being bare. From 6 to 9 dark brown bands cross the rachis continuing on to the filaments. The lesser number occurs where the bands have coalesced and are accordingly broader. Similar pigment shows on the uncinal region of the thorax, but elsewhere the body is uncolored. The opercular stalk is formed of the dorsalmost rachis of one side. I cannot say if it is always on

the same side. In normal conditions the operculum is evidently spherical, but in most of my material it is more or less wrinkled. It sometimes contains rounded bodies (fig. 1), commonly regarded as eggs, but they more probably are, as maintained by McIntosh (1926), masses of coagulated blood. The collar (fig. 1), is one-lobed, the halves separated on the dorsal surface. The thoracic membrane is obscure, most clearly visible at its posterior end. The eggs, in the specimen drawn, were lying between the thoracic membrane and the body wall.

There are 6 thoracic somites. On the first is a tuft of rather long setae which are toothed on the terminal portions. At the base of the tuft are a

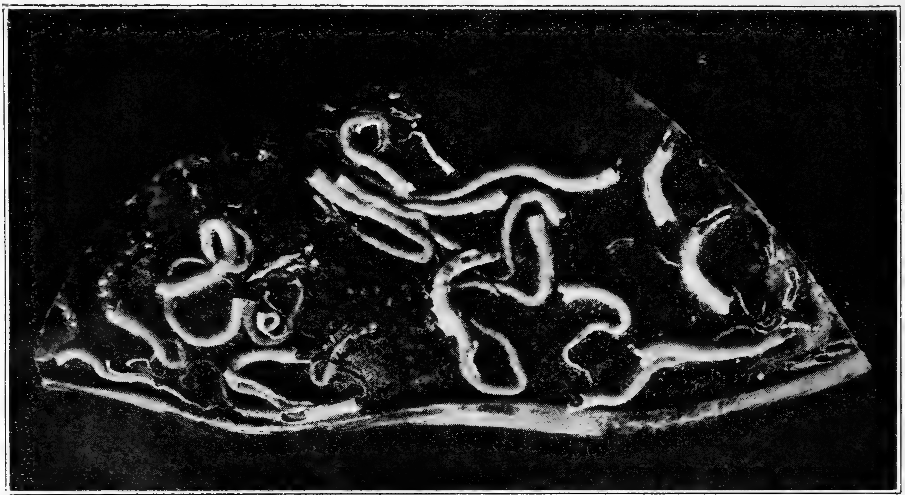


Fig. 9.—Part of carapace of *Macrobrachium jamaicense* showing worm tubes, ×2.

few very small and slender simple setae without any teeth. Other thoracic setae are smooth, sharp-pointed and not limbate. Uncini begin on the second thoracic somite and continue throughout the body in a single row in each torus. The toothed setae of the first somite are of especial interest. Each (fig. 3) is widened toward the end and then curves to end in a sharp point. At the widening is a double row of teeth, only one row being visible in profile. The basal teeth are very small, the following ones are larger as far as the fifth which is the heaviest of all. Beyond this there is a progressive diminution in size. The other thoracic setae are as described above. The thoracic uncini are extremely small, but under a magnification of 1200 diameters it is possible to see that each carries 10 minute sharp teeth and a basal knob (fig. 5). Abdominal uncini are similar to these but are more narrowly triangular in form. Abdominal setae are geniculate and small, carrying minute denticulations along the margin of the blade (fig. 4). Especially in the posterior abdominal somites these have very long shafts which extend to a considerable distance from the body wall.

The pygidium is bilobed, each lobe short and thick.

The tubes containing the animals were found attached to the carapace of a shrimp *Macrobrachium*. They are very small at the beginning but enlarge rapidly. In cross section they are circular and the surface is smooth (fig. 9).

Three genera of serpulids having toothed setae in the first somite have been described, all found in water supposedly fresh, but probably more or less brackish. *Mercierella* Fauvel (1922, pp. 424–430) was originally found in a canal at Caen, France, and *Ficopomatus* Southern (1921, p. 655) was collected in Chilka Lake, India. *Sphaeropomatus* differs from *Mercierella* in not having a prominent reflexed collar and in having an operculum devoid of spines. As figured by Munro (1924, p. 655), *Mercierella* has prominent spines on the surface of the operculum (fig. 6). The toothed setae are similar in the two genera as are the uncini, but from figures given by Fauvel and Munro I infer that the latter are much smaller in *Sphaeropomatus*. The tube of *Mercierella* has at intervals circular shelf-like rings which do not appear in *Sphaeropomatus*. For *Ficopomatus* Southern does not give the character of the collar, but the operculum (fig. 8) and the toothed setae are very different. A comparison of the two setae is given in figs. 3 and 7. The tube of *Ficopomatus* is described as flattened along the line of attachment and as having a longitudinal ridge along its outer border.

The type is No. 20074 in the collections of the United States National Museum.

The specimens were sent me by Dr. W. L. Schmitt of the U. S. National Museum, who found them when studying the shrimp *Macrobrachium* from the Miami River, Florida. I am also indebted to Dr. Schmitt for portions of the carapace of the shrimp on which were a number of tubes. Acknowledgment is made to Mr. C. R. Shoemaker for sending the precise diagnosis of *Ficopomatus*.

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McINTOSH, W. C. *On the structure and functions of the operculum and neighbouring parts of* Mercierella enigmatica *and other Serpulids.* Ann. and Mag. Nat. Hist., Ser. 9, **18:** 402–421, *pl. 13, figs. 1, 2, 4, 5, 6, pl. 14, figs. 1, 2, 4,* 1926.

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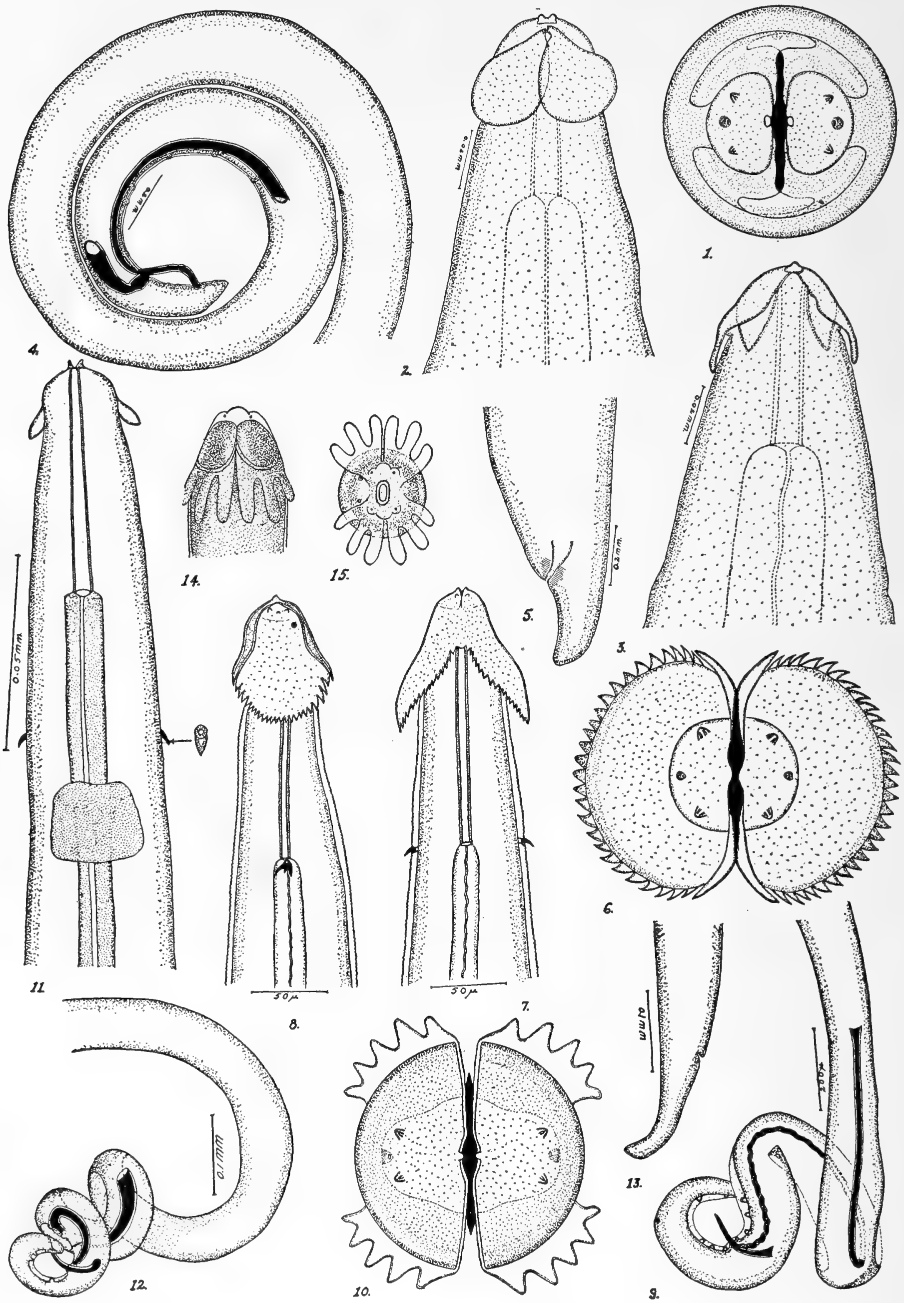
ZOOLOGY.—*Descriptions of three bird nematodes, including a new genus and a new species.*[1] EVERETT E. WEHR, Bureau of Animal Industry. (Communicated by ELOISE B. CRAM.)

I

The first lot of nematodes to be described and figured in this paper was collected from a king rail, *Rallus elegans*, by Dr. Albert Hassall in 1893. The preserved specimens, consisting of two males and three females and representing a new species, *Schistorophus cucullatus*, were

[1] Received March 12, 1934.



Figs. 1–15.—For explanation see opposite page.

in excellent condition for study. This paper includes, apparently, the first record of a species of the genus *Schistorophus* to be recorded from this continent. The members of this genus represent a very interesting and little studied group of nematodes.

Schistorophus cucullatus new species

Diagnosis.—Schistorophus: Oral opening dorso-ventrally elongated, surrounded by 2 pseudolabia from which project anteriorly 2 cuticular processes, 1 on each lateral side of mouth opening (Fig. 1); interlabia absent. A pair of submedian papillae and an amphid on each pseudolabium. Two dorsal and 2 ventral flap-like cuticular structures arranged in form of hood surrounding anterior extremity of body just posterior to pseudolabia (Figs. 2 and 3), 1 flap of each pair slightly overlapping the other in dorsal and ventral views (Fig. 2). Buccal cavity cylindrical and well developed, its wall heavily chitinized. Esophagus divided into an anterior muscular and a posterior glandular portion.

Male 10 to 11 mm. long and 77μ in maximum width. Buccal cavity about 100μ long. Anterior portion of esophagus about 810μ, posterior portion 1.42 mm., long. Nerve ring 220μ from anterior end of body. Posterior extremity spirally coiled in ventral direction, tip abruptly pointed. Caudal alae narrow, about 1 mm. long. Six pairs of preanal and 4 pairs of postanal papillae (Fig. 4). Spicules unequal and dissimilar, the longer 1.1 mm. long and terminating in a bluntly rounded tip, the shorter about 300μ long, broad and twisted at distal end.

Female 28 mm. long and 315μ in maximum width. Buccal cavity about 115μ long. Anterior portion of esophagus presenting a laterally displaced loop near middle of length due, perhaps, to fixation, and measuring in a straight line about 810μ long; posterior portion 1.88 mm. long and only slightly wider than anterior portion. Nerve ring about 220μ from anterior end of body. Posterior extremity abruptly narrowed at level of anus, tip abruptly pointed (Fig. 5). Vulva 14.3 mm. from anterior end of body, not prominent. Vagina directed posteriorly. Tail about 300μ long. Eggs 48μ by 32μ, with very thick shells, not embryonated *in utero.*

Host.—Rallus elegans.

Location.—Underneath tunic lining of gizzard.

Locality.—North America (United States [Virginia]).

Type specimens (male and female).—U.S.N.M. Helminthological Collection, No. 6268-A.

Paratypes.—U.S.N.M. Helminthological Collection No. 6268-B.

Figs. 1–5.—*Schistorophus cucullatus.* Fig. 1.—Head, en face view. Fig. 2.—Anterior extremity, dorsal view. Fig. 3.—Anterior extremity, lateral view. Fig. 4.—Posterior extremity of male, lateral view. Fig. 5.—Posterior extremity of female, lateral view. Figs. 6–9.—*Stegophorus stellae-polaris.* Fig. 6.—Head, en face view. Fig. 7.—Anterior extremity, dorsal view. Fig. 8.—Anterior extremity, lateral view. Fig. 9.—Posterior extremity of male, lateral view. Figs. 10–15.—*Yseria coronata.* Fig. 10.—Head, en face view. Fig. 11.—Anterior extremity, dorsal view. Fig. 12.—Posterior extremity of male, lateral view. Fig. 13.—Posterior extremity of female, lateral view. Fig. 14.—Head, en face view. After Drasche, 1884. Fig. 15.—Head, lateral view. After Drasche, 1884.

Molin (1) described a species of nematode, *Histiocephalus laciniatus*, from the gizzard of the rail, *Rallus cayennensis;* this species was later transferred to the genus *Schistorophus* by Railliet (2) in 1916. However, inasmuch as *Schistorophus laciniatus* is described as 7 mm. and 14 mm. long, in case of male and female respectively, with head encircled by a fringe of long slender processes and with male tail bearing 24 papillae, the American material here described is considered distinct from that species. The possibility is recognized, however, that *S. cucullatus* may prove to be a synonym of *S. laciniatus* should the type material of the latter species be more completely described. *Schistorophus cucullatus* may be differentiated from the other better described species of this genus by its having fewer papillae on tail of male, by its much larger size, and its differently shaped head structures.

II

The second lot of nematodes was collected by the Bureau of Biological Survey from the fulmar, *Fulmarus glacialis glacialis*, and the Brunnich's murre, *Uria lomvia lomvia*, in the arctic region, the locality designation being that given below. The writer has identified this material as a species described by Parona (3) as *Histiocephalus stellae-polaris*.

The systematic position of *H. stellae-polaris* has been uncertain because of its too meagre description. The species was placed in *Streptocara* by Skrjabin (4) and in *Yseria* by Gedoelst; (5) however, according to the more complete description of this species herein given, it cannot be allocated to any of these genera, for the reasons discussed below. As a result a new genus, *Stegophorus*, has been created for it.

Stegophorus new genus

Diagnosis.—Acuariidae: Oral opening dorso-ventrally elongated, surrounded by 2 pseudolabia, each bearing a pair of submedian papillae and a small amphid (Fig. 6). A helmet-like cuticular structure surrounding head, not extending farther anterior than base of pseudolabia; posterior margins denticulated. Buccal cavity cylindrical, elongated; its wall cross-striated. Esophagus consisting of an anterior short, narrow, muscular portion and a posterior long, broad, glandular portion. *Male*: Caudal alae well developed, terminating slightly anterior to tip of tail. Four pairs of preanal and 5 pairs of postanal pedunculated papillae. Spicules very unequal and dissimilar, the longer one assuming a braided or closely twisted condition in posterior half. Gubernaculum absent. *Female:* Vulva postequatorial. Uteri divergent. Eggs embryonated *in utero*.

Type species.—*Stegophorus stellae-polaris* (Parona, 1901) n. comb.

Stegophorus stellae-polaris (Parona, 1901) n. comb.

Synonyms.—*Histiocephalus stellae-polaris* Parona, 1901; *Streptocara stellae-polaris* (Parona, 1901) Skrjabin, 1916; *Yseria stellae-polaris* (Parona, 1901) Gedoelst, 1919.

Diagnosis.—Stegophorus: Helmet-like cuticular structure (Figs. 7 and 8) surrounding anterior end of body, 87.6μ long, and denticulated on free margins; this structure not in form of a collarette around base of pseudolabia as in *Yseria, Streptocara*, and *Seuratia.* Extremities of body attenuated, the anterior more gradual than posterior. Cervical papillae tricuspid, situated at level of junction of buccal cavity with anterior portion of esophagus. Nerve ring near equator of anterior portion of esophagus.

Male 5 to 6 mm. long and 102μ in maximum width. Buccal cavity about 190μ long. Anterior portion of esophagus 400μ long and 15 to 20μ wide; posterior part 1.28 mm. long and about 30 to 40μ wide. Cervical papillae (Fig. 8) about 180μ from anterior end of body. Spicules (Fig. 9) very unequal and dissimilar, the longer 1.6 to 2.43 mm. long, slender, enlarged proximally and pointed distally, with the posterior half, except tip, appearing as a twisted rope, the twisting grading into a braided condition in the distal third; shorter spicule 65 to 100μ long, slightly curved and gradually narrowing towards tip. Caudal alae relatively broad and long, supported by 4 pairs of preanal and 5 pairs of postanal papillae, the latter arranged as follows: 3 pairs just posterior to anal opening, 1 pair near tip of tail, and 1 pair slightly more than one-half the distance from anal opening to tip of tail.

Female 12 to 16 mm. long and 148μ in maximum width. In specimen 13 mm. long, buccal cavity 200μ long, anterior portion of esophagus 511μ long and about 20 to 25μ wide, posterior portion 1.38 mm. long and about 35 to 45μ wide, cervical papillae 204μ and vulva 7.05 mm. from anterior end of body; position of latter indicated by a slight cone-shaped prominence. Vagina directed posteriorly. Amphildelphic. Posterior extremity obtusely rounded, curved slightly ventrad. Anal opening about 200μ from tip of tail. Eggs 44μ by 24μ, embryonated *in utero.*

Hosts.—Fulmarus glacialis glacialis, Thalassodroma pelagica, Uria lomvia lomvia.

Location. Not stated; probably underneath tunic lining of gizzard.

Locality.—Arctic region and British Isles. No specific locality in arctic region was designated by Parona; the recent collections were made at Lat. 73.20 N., Long. 17.25 W. and Lat. 72.00 N., Long. 13.30 W., for *Uria lomvia lomvia.* Lat. 61.00 N., Long. 32.10 W., for *Fulmarus glacialis glacialis*, according to the Bureau of Biological Survey. Baylis (6) reported *Streptocara? stellae-polaris* from the fulmar petrel (*Fulmarus glacialis*) in the North Sea, and the storm-petrel (*Thalassodroma pelagica*) in Norfolk, England

The above redescription is based on specimens in the U.S.N.M., Bureau of Animal Industry, Helminthological Collection, Nos. 33233 and 33234.

Parona described *Histiocephalus stellae-polaris* on the basis of a single female specimen from the fulmar, *Fulmarus glacialis*, taken in the Arctic region. His very meagre illustrated description (taken from Cram (7) is as follows:

"Head with two large lips and a dilation in manner of a hood with denticulate margin. A tricuspid process a little posterior to this dilation. Male unknown. Female 16 mm. long. Anus at caudal extremity, the latter obtuse. Vulva at middle of body. Eggs oval, containing an embryo when deposited."

The specimens examined by the present writer which were collected from the same host and in the same general locality as Parona's specimen, possess characters that identify it with the latter's species; *Histiocephalus stellae-*

polaris has, therefore, been redescribed from this additional material. The erection of a new genus was considered necessary because of the absence of a swollen bulla in the cervical region, such as is present in species of *Histiocephalus*, and because of the helmet-like structure covering the head, and the peculiar structure of the posterior half of the long spicule, differing from these characters in the genera *Histiocephalus*, *Streptocara*, and *Yseria*.

III

The third lot of nematodes considered here consisted of a number of small and very delicate specimens, both males and females, collected in May, 1930, by E. B. Cram from the gizzard of a king rail, *Rallus elegans*, killed in St. Mary's County, Maryland. These have been identified as *Yseria coronata* (Molin, (8) 1860) Gedoelst, (5) 1919. From this material, it is possible to furnish a more adequate description than has been previously available.

YSERIA CORONATA (Molin, 1860) Gedoelst, 1919

Synonyms.—Spiroptera coronata Molin, 1860; *Histiocephalus coronatus* (Molin, 1860) Skrjabin, 1916.

Diagnosis.—Yseria: Body slender, delicate. Oral opening dorso-ventrally elongated, surrounded by 2 pseudolabia with 2 finger-like cuticular processes projecting anteriorly from their internal margin near the oral opening (Fig. 10). Each pseudolabium bearing near its base 2 submedian papillae and an amphid. Cephalic ornamentation in form of 4 posteriorly directed flaps, each flap divided into 3 or 5 finger-like processes (Figs. 10, 14 and 15). Body slightly constricted at base of head. Cervical papillae (Fig. 11) consisting of only a single tooth. Buccal cavity long, cylindrical. Esophagus divided into an anterior short and a posterior long portion.

Male 8 to 9.5 mm. long and 76μ in maximum width. Buccal cavity (Fig. 11) about 68μ long. Anterior muscular portion of esophagus 680μ, posterior glandular portion 1.94 mm., long. Nerve ring surrounding anterior portion of esophagus about 140μ from anterior extremity. Posterior extremity spirally coiled (Fig. 12) in a ventral direction, and gradually narrowing to a bluntly rounded point. Caudal alae terminating slightly anterior to tip of tail. At least 8 pairs of caudal papillae: 3 pairs of preanal and 5 pairs of postanal (it is possible that 1 or 2 additional pairs of caudal papillae were obscured because of the extremely coiled condition of the posterior extremity). Spicules unequal and dissimilar, the longer about 300μ long, relatively broad at the proximal end; shorter spicule about 88μ long, knob-like at proximal end, pointed at distal end.

Female 12 to 21 mm. long and 85 to 94μ in maximum width. In a specimen measuring 21 mm. long, buccal cavity 85μ long, anterior muscular portion of esophagus about 780μ, posterior glandular portion 2.42 mm., long, nerve ring 146μ and vulva 10.3 mm. from anterior extremity of body. Posterior extremity (Fig. 13) bent slightly dorsad, bluntly rounded. Anal opening 1.72 mm. from posterior end. Eggs 44μ by 17μ.

Hosts.—Chloroceryle americana (syn., *Alcedo americana*), *Rallus cayennensis*, and *R. elegans*.

Location.—Gizzard.

Locality.—South America (Brazil) and North America (United States [Maryland]).

Redescription based on specimens in U.S.N.M., Bureau of Animal Industry, Helminthological Collection No. 29839.

Drasche (9) figured (Figs. 14 and 15) and described this species as follows (translated): "Head with oval mouth opening. Two large lateral lips, each divided into 3 parts, the lateral ones bearing small papillae. Two posteriorly directed processes on each side of head, each process divided into 3 finger-like projections. Four submedian papillae. Tail of male incomplete."

Because of the lack of knowledge concerning the number of caudal papillae possessed by the male, Drasche left this species in the genus *Spiroptera* as originally placed by Molin. He stated, however, that should the posterior extremity of the male of this species possess 4 preanal caudal papillae and unequal spicules, it would belong to the genus *Histiocephalus*. Skrjabin (4) later reallocated the species to that genus, although stating that its position there was doubtful. According to the present accepted diagnosis of the genus *Histiocephalus*, the cervical region is swollen into a bulla consisting of numerous longitudinal folds; this is not the case in *Yseria coronata*.

The presence of only a single tooth on the cervical papilla differentiates this species from *Y. californica* which is said to possess cervical papillae with 3 teeth each; the male of *Y. californica* is as yet undescribed, so that comparison of the two species is limited. The generic diagnosis of *Yseria* must now be modified with respect to the cervical papillae, to designate them as each having 1 to 3 cusps; also as regards the position of the vulva, to designate it as being slightly pre-equatorial or slightly post-equatorial.

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ZOOLOGY.—*Some Actinaria from Bering Sea and arctic waters.*[1]
OSKAR CARLGREN, Zoological Institute, Lund, Sweden. (Communicated by MARY J. RATHBUN.)

At the end of 1933 I received from the United States National Museum for examination a small collection of Actinaria taken by Capt. R. A. Bartlett in the course of his expeditions into arctic waters during the past decade. As our knowledge of the Actinarian fauna in the Bering Sea and in the waters continuous with it is very imperfect and every contribution to it interesting, I have taken the liberty of adding to the list of the National Museum collection some specimens from the Swedish expeditions to Kamchatka and the Aleutian Islands (designated in brackets with the letters R.M.). The descriptions of several species, previously imperfectly examined, are here somewhat extended. One species, *Epiactis ritteri* Torrey I have referred to a new genus, *Cnidopus.*

Family PTYCHODACTIIDAE

1. PTYCHODACTIS PATULA App. Mouth Kotsebue Sound, Alaska, Bartlett, 1924, 1 specimen.

The discovery of this species north of Bering Strait is very interesting as it has been taken previously only in Trondheim Fjord, north of Iceland and more recently in Malangen, Norway, at a depth of 350 m. In 1921 (Actiniaria. The Ingolf Exped., **5**: 12.) I stated that the throat is not so much reduced as Appellöf described it. In fact the throat in the present specimen is 1–1.5 cm. long; the column, which is rather strongly contracted, 3 cm.

Family HALCAMPIDAE

2. HALCAMPA ARCTICA Carlgr. E. of Alger Island, Alberdare Channel, Franz Joseph Land, Baldwin-Ziegler Expedition, 1901, numerous specimens.

Family CONDYLANTHIDAE

3. CHARISEA SAXICOLA Torrey. Unalaska, Aleutian Islands in pools during the ebb, 3 specimens, Hultén, 1932 (R.M.).

This species appears to be a Condylanthid, though it is not identical with *Charisea,* as Stephenson (Quart. Journ. Micros. Soc. **66**: 262.) suggests. The small specimens examined, the largest being only 0.7 cm. long, are little suited to answering this question because the proximal part of the body is introverted, but there seem to be rather distinct basilar muscles. Also the fact that there are a few more mesenteries than tentacles in the greater part of the body would seem to place the species in the family Condylanthi-

[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 19, 1934.

dae. The sectioned specimen has 27 mesenteries, 6+6 pairs and 3 unpaired of the third order, one on one side of the directive plane, two on the other, but only 22 tentacles. Only the mesenteries of the first order are macrocnemes. The gonads, here ovaries, are only little developed. The nematocysts of the column are partly 15–24×4.5μ (penicilli often curved), partly 14–17 ×about 2.5μ, partly 12–13×1μ; those of the tentacles partly 17–21×3.5–4.5μ (often curved), partly 15–19×2–2.5μ (very numerous).

Family ACTINIIDAE

4. TEALIA (URTICINA) FELINA L. var. CRASSICORNIS. Cape Lisburne, Alaska, beach, H. D. Woolfe, 1835, 1 specimen; mouth Kotsebue Sound, Alaska, Bartlett, 1924, 1 specimen; 62° 15′ 20″ N., 167° 48′ W., Stoney, 1884, 2 specimens; 20 miles off Devil's Mountain, Alaska, Bartlett, 1924, 1 specimen; Wrangell, Alaska, 2 specimens; W. Greenland, 70° 20′ N., 56° W., off Hare Island, 10–15 fms., McClain, 1884, 2 specimens; N.E. Greenland, Clavering Island, 10–35 fms., Bartlett, 1930, 4 specimens; var. *coriacea*, Bering Island, L. Stejneger, 1882–83, 1 large specimen provided with distinct, although somewhat introverted, but rather large verrucae. Therefore, I think that the specimen may be *coriacea* or possibly *tuberculata*, at any rate neither *crassicornis* nor *lofotensis*.

The discovery of a tuberculated form of *Tealia* at Bering Island is very interesting as showing that in Bering Sea, as well as in the Atlantic, smooth forms occur to the north, tuberculated forms to the south.

5. CRIBRINOPSIS SIMILIS Carlgr. W. Greenland, 70° 20′ N., 56° W., 90 fms., McClain, 1884, 1 imperfect specimen.
6. BUNODACTIS SPITZBERGENSIS Carlgr. Greenland, Bartlett, 1 specimen.
7. BUNODACTIS STELLA Verr. Unalaska, Aleutian Islands, Hultén, 1932, 3 specimens (R.M.).

Verrill states, 1922 (Report Canadian Arctic Exped., 1913–18, 8. G, p. 112), that the number of tentacles may amount to 72, sometimes to 120. The present specimens are considerably larger than those previously described by me (*l.c.* 1921, p. 148) and had more tentacles. One specimen which was examined more closely is provided with about 96 tentacles and mesenteries, and its sphincter is distinctly palmate circumscript.

8. ANTHOPLEURA XANTHOGRAMMICA (Brandt). Saginaw Bay, Alaska, beach, W. H. Jones, 3 specimens; Wrangell, Alaska, 1915, 2 specimens; Bering Island, L. Stejneger, 1882–83, 1 specimen; Nikolski, Bering Island, L. Stejneger, 1897, 3 specimens; Petropaulovsk, Kamchatka, stony beach, low water, Swedish exped., 1921, 1 specimen (R.M.).

The species is described from Port Townsend by McMurrich (Ann. N. Y. Acad. **14**: 36. 1901.), who, moreover, mentions that it occurs also at San Francisco. It is possible that some of McMurrich's specimens belong to

xanthogrammica, but some others may be another species. According to McMurrich, Dr. Calkins states "that evidences of multiplication by fission were not infrequent among the Port Townsend specimens." I have not found any indication of such a reproduction. The 5 specimens, taken from three localities and examined by me are provided with 96 mesenteries and about an equal number of tentacles. Also the sphincter seems to be different. In McMurrich's specimen they are palmate circumscript; in our specimens they are pinnate and resemble the sphincter of *Epiactis ritteri,* although the

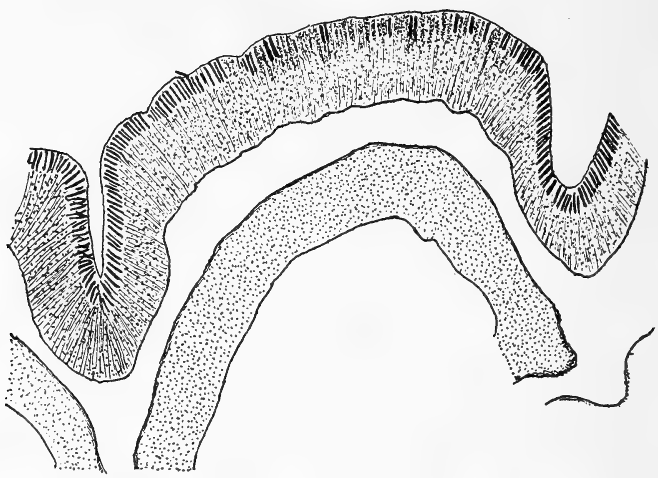

Fig. 1.—*Cnidopus ritteri.* Almost transverse section of a protuberance showing the distribution of the nematocysts (the black rods). Between the nematocysts in the middle of the protuberance are many gland cells.

main lamella here is thinner. Komai and Ikari (Records Oceanographic Works Japan **1**: 120. 1929.) mention *xanthogrammica* from Tanabe Bay, not far from the southernmost point of the main island of Japan, but this may be another species, possibly *Anthopleura japonica* Verr. In our specimens, preserved in alcohol, the tentacles, including their apices, the oral disc, and the upper part of the column are greenish, the marginal sphaerules and the actinopharynx colorless, the pigment being situated in the endoderm. I have more closely examined a specimen the mesenteries of which are arranged $6+6+12+24=48$ pairs, 2 of which are directives. All mesenteries except the directives are fertile; all or almost all perfect. The pennons are considerably stronger than those figured by McMurrich and remind one of those of *Tealia felina.* The parietobasilar and the basilar muscles are strong. The marginal sphaerules are large in a specimen from Bering Island, corresponding with the endocoels as well as with the exocoels. Meanwhile, the number and size of the marginal sphaerules vary, as is common in species having such organs. In another specimen they are smaller and more sparse, and in the two specimens from Kamchatka I could not find any. It is possible, however,

that they are present but very small and few in number. The nematocysts of the marginal spherules in three specimens examined are (50) 55–67, 55–68, 55–69×3.5–4.5μ, those of the lower part of the column (one specimen examined) 18–22×2–2.5μ, those of the uppermost part 14–17×1.5–2μ, those of the tentacles 17–22×(2) 2.5μ (very numerous), those of the actinopharynx 23–26×2.5μ.

Cnidopus, new genus

Actiniid with broad pedal disc. Column smooth, in the lower part, from the limbus upward, provided with transverse and longitudinal rows of low protuberances square at the base and very close together. The sides of these protuberances and the furrows between them form strong nematocyst batteries. Sphincter circumscript. Tentacles rather short, comparatively numerous, as a rule arranged hexamerously. Longitudinal muscles of the tentacles and radial muscles of oral disc ectodermal. Mostly 2 siphonoglyphes. Mesenteries for the most part perfect, and more numerous than the tentacles. Pennons of the mesenteries not strong, parietobasilar and basilar muscles strong. Mesenteries of the first and second cycles probably sterile.

9. CNIDOPUS RITTERI (Torrey). St. Georges Island, Alaska, G. D. Hanna, 1914, 7 specimens. ? Nikolski, Bering Island, Stejneger, 1897, 1 specimen.

This species, described and referred by Torrey (Proc. Washington Acad. Sci. **4**: 393. 1902.) to the genus *Epiactis* is here referred to a new genus for which I propose the name *Cnidopus* owing to the very numerous nematocysts present at the sides of the protuberances and between them in the lowest part of the column. Torrey describes the exterior of the column in the following manner: "The body-wall is smooth, without true verrucae, though near the foot there may be ten or twelve rows of protuberances which slightly resemble them. They are caused by transverse and longitudinal wrinkles and are of the same histological character as the rest of the wall. They vary greatly in size even in the same individual." (See fig. 6, pl. 25 in Torrey's paper). Our specimens show the same exterior, so that it is clear that we have to do with *E. ritteri*. Like Torrey's, our specimens are rather strongly contracted, wherefore it is probable that the protuberances, in our specimens arranged in 8–14 longitudinal rows, in the extended state have a more vesicle-like appearance. The histological structure of the protuberances is, however, other than Torrey stated. The sides of the protuberances and the furrows are provided with very numerous nematocysts standing, as in the marginal sphaerules, very close together. Only in the middle of the protuberances the nematocysts, especially the larger, are sparse or almost lacking on some protuberances more than on others. (Fig. 1). There are two sizes of these nematocysts—unfortunately they are opaque, so that I cannot decide their structure—the larger of which reach a size not observed by me in the vesicles of any one Actiniid (including Phyllactids) except in the marginal sphaerules. The size of the larger nematocysts varies in 4 specimens

between 31–41×4.5–5μ, (35–41×4.5–5μ, 32–41×4.5μ, 31–41×4.5–5μ, and in the smaller specimen 31–36×4.5μ); the smaller between 17–26×2–2.5μ (22–26×2–2.5μ, 21–26×2–2.5μ, 19–24×2–2.5μ, 17–22×almost 2.5μ in the smallest specimen). In the other parts of the column only the small nematocysts (17–24×about 2.5μ) are present, although I observed in some macerated preparations a few larger nematocysts, possibly stuck to the ectoderm. The sphincter is in all specimens pinnate circumscript, as is that figured by Torrey. The longitudinal muscles of the tentacles and radial muscles of the oral disc are well developed and palisade-like arranged. Three specimens examined have 2 siphonoglyphes and 2 pairs of directives. One specimen more closely examined has 192 mesenteries, but only 172 tentacles, thus the number of tentacles is fewer than that of the mesenteries. All mesenteries are perfect, except those of the last cycle and possibly some of the fourth. Torrey stated that the mesenteries of the last cycle were sterile, all others fertile. Although the strong contraction of the large specimen examined makes it difficult to determine exactly the distribution of the gonads, I am able to state that the mesenteries of the fifth (the last cycle), fourth, and partly those of the third cycles have ovaries; on the other hand, I have not observed any on the mesenteries of the first and second cycles. The pennons of the mesenteries are rather thin, the parietobasilar muscles broad and reaching almost the margin, the basilar muscles well developed, oral and marginal stomata present. The nematocysts of the tentacles are in 5 specimens 29–32×2.5μ; 26–30×2 (2.5) μ, 24–29×2μ, 26–31×almost 2.5μ, 19–29×almost 2.5μ (in the smallest specimen); those of the actinopharynx 27–32 ×2.5μ, 26–30×2.5μ, 26–29×2.5μ, 29–32×2.5μ (in one specimen I find also some large nematocysts 29–36×4.5–5μ, possibly stuck to the ectoderm). The penicilli of the filaments are in one specimen 26–31×4.5–5μ, the spirocysts of the tentacles 22–43×2.5—almost 3.5μ, 22–41×3.5μ (2 specimens examined).

Family ACTINOSTOLIDAE

10. STOMPHIA COCCINEA (O.F.M.). Coal station near Cape Lisburne, Alaska, beach after 4 days of N.W. gale, H. D. Woolfe, 1885, 3 specimens; Saglek Bay, Labrador, Bartlett, 1925, 1 specimen.
11. ACTINOSTOLA SPITZBERGENSIS Carlgr. Mouth Kotsebue Sound, Alaska, Bartlett, 1924, 1 specimen; 20 miles off Devil's Mountain, Alaska, 16–18 fms., mud bottom, Bartlett, 1924, 2 specimens; Clavering Island, N.E. Greenland, 10–35 fms., Bartlett, 1930, 1 specimen.

Family HORMATHIIDAE

12. HORMATHIA NODOSA (Fabr.). Entrance to Fury & Hecla Straits, Baffin Land, Norcross & Bartlett, 1933, 1 specimen; Saglek Bay, Labrador, Bartlett, 1925, 1 specimen; 70° 20′ N. off Hare Island, W. Greenland, 2 specimens; Clavering Island, N.E. Greenland, 10–35 fms., Bartlett, 1930, 3 small specimens; Greenland, Bartlett, 1 specimen; 80° 22′, N.W.

coast of McClintock Island, Franz Joseph Land, Baldwin-Ziegler Exped., 1902, 1 specimen.

13. METRIDIUM SENILE (L.) var. FIMBRIATUM. St. Michaels, Norton Sound, Alaska, E. W. Nelson, 1879–80, low water, 3 specimens; Unalaska, Aleutian Islands, Hultén, 1932, 5 specimens (R.M.); Petropaulovsk, Kamchatka, Swedish Kamchatka Exped., 1921, 4 specimens (R.M.); Awatcha Bay, Swedish Kamchatka Exped., 1921, some small specimens (R.M.); Achomten Bay, Swedish Kamchatka Exped., 1920, 1 specimen (R.M.).

Among the specimens from Unalaska there is a small one (0.5×0.6 cm.), the nematocysts of the acontia of which are: Penicilli 47–58×about 5μ, spirulae 47–57×3–3.5μ. In a small specimen of the variety *dianthus* of about the same size as the variety *marginatum* the penicilli of the acontia are 46–50 ×almost 5.5μ, the spirulae 38–50×3–3.5μ. Thus it seems that also young specimens of *marginatum* have larger nematocysts than *dianthus* in the acontia (compare Carlgren, *The Godthaab Exped.*, 1928. Medd. om Grønland **79**: 23–24. 1933.).

ZOOLOGY.—Neodiplostomum pricei *n.sp., a new trematode from a gull,* Larus novaehollandiae.[1] WENDELL H. KRULL, Bureau of Animal Industry. (Communicated by MAURICE C. HALL.)

The fluke described in this paper was obtained from an Australian silver gull, *Larus novaehollandiae* Stephens, which had been experimentally infected by feeding it fish, *Fundulus diaphanus diaphanus* and *F. heteroclitus macrolepidotus,* containing metacercariae of the neascus type. The species appears to be new and for it the name *Neodiplostomum pricei* is proposed.

Neodiplostomum pricei n. sp.

(Figs. 1–2)

Description.—Neodiplostomum: Body small, distinctly separated by constriction into a forebody and hindbody. Forebody 1.2 mm. to 1.6 mm. (average 1.4 mm.) long by 600μ to 665μ (average 632μ) wide, spoon-shaped, relatively thin and leaf-like, without glands and lateral sucking cups; hindbody 550μ to 880μ (average 748μ) long by 410μ to 520μ (average 472μ) wide, roughly cone to acorn-shaped when bursa copulatrix is withdrawn. Cuticula provided with fine spines extending from anterior end to level of holdfast organ. Oral sucker 37μ to 60μ (average 47μ) long by 30μ to 44μ (average 38μ) wide and subterminal. Mouth opening into a short prepharynx about one-third as long as pharynx. Pharynx 33μ to 53μ (average 43μ) long by 26μ to 41μ (average 33μ) wide. Esophagus twice as long as pharynx, bifurcating to form narrow, thin-walled ceca extending to near level of posterior end of posterior testis; ceca ventral in position in hindbody. Acetabulum 55μ to 92μ (average 76μ) long by 73μ to 112μ (average 91μ) wide, midway between

[1] Received April 17, 1934.

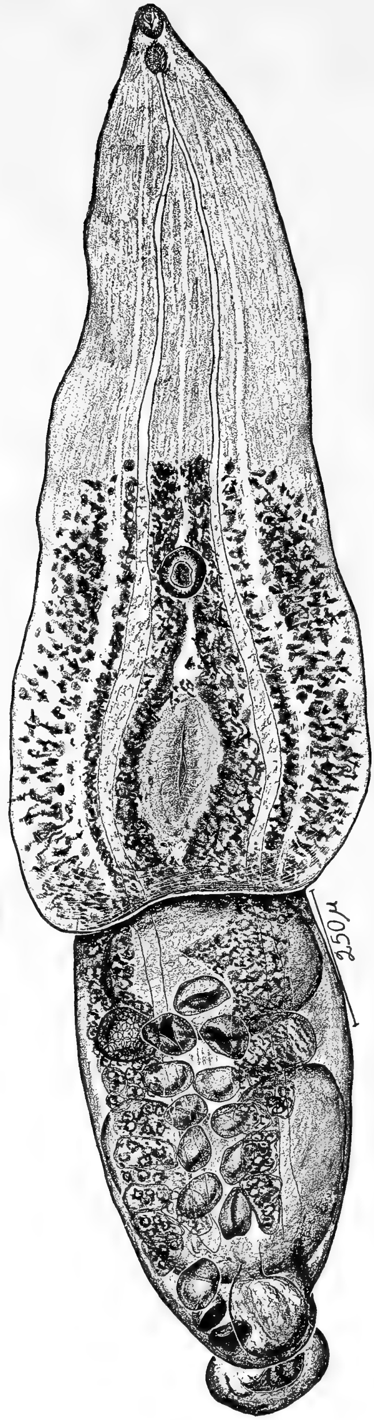

Fig. 1.—*Neodiplostomum pricei*. Entire worm.

holdfast organ and anterior end of vitelline area. Holdfast organ large, 310μ long when extended (Fig. 2b), with median longitudinal cleft when retracted. Testes large, tandem, filling greater part of hindbody; anterior testis 230μ to 318μ (average 280μ) long by 295μ to 425μ (average 387μ) wide, transversely oval; posterior testis 280μ to 360μ (average 330μ) long by 372μ to 470μ (average 435μ) wide, reniform, wider than long, somewhat larger than anterior testis. Vas deferens broad and extending to near posterior end of posterior testis, expanding there and forming a voluminous, folded seminal vesicle filled with spermatozoa, discharging into genital atrium through a

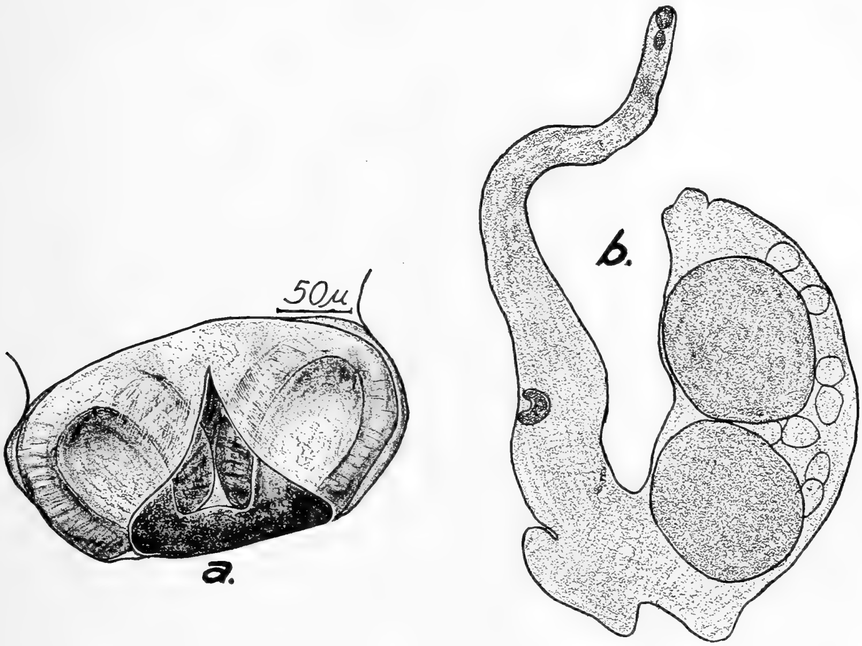

Fig. 2.—*Neodiplostomum pricei.* (*a*) Bursa copulatrix, expanded, dorsal view; (*b*), complete specimen flexed dorsally, showing expanded hold-fast organ.

short ejaculatory duct. Ovary 110μ to 140μ (average 120μ) long by 86μ to 122μ (average 104μ) wide, ventral, either to right or left of median line, at, and usually overlapping postero-lateral margin of anterior testis. Oviduct arising on postero-dorsal face of ovary, continuing in postero-dorsal direction and uniting with Laurer's canal, turning, continuing somewhat anteriorly, uniting with common vitelline duct, and then continuing as oötype. Laurer's canal opening dorsally in median line near level of posterior margin of ovary. Mehlis' gland large, surrounding oötype. Uterus voluminous, with short ascending limb turning at level of anterior testis and continuing posteriorly as descending limb, extending in median line ventral to all organs except vitellaria, and terminating at genital atrium. Proximal portion of uterus usually filled with spermatozoa, and in stained and mounted specimens sometimes folded in such a way as to appear as a spherical seminal receptacle equal in size to, and opposite, ovary. Vitellaria occupying area from middle of anterior body to end of posterior testis; vitelline follicles extending dorsally and ventrally in anterior body and in portion of posterior

body in front of anterior testis, and ventrally in remaining part of posterior part of body; vitelline follicles in anterior part of body relatively small, and those in posterior part very large. Common vitelline duct with mostly a dorso-ventral course; expanded to form a vitelline reservoir. Eggs from preserved flukes averaging 86μ long by 66μ wide, those from living flukes averaging 92μ long by 72μ wide. Details of bursa copulatrix shown in figure 2a.

Host.—*Larus novaehollandiae* Stephens (experimental).

Location.—Small intestine.

Distribution.—United States (Washington, D. C.)

Type specimens.—U.S.N.M. Helm. Coll. No. 32880; *paratypes* No. 32881.

This description is based on 25 of 80 specimens recovered from a single gull. Some of the flukes were killed under pressure in corrosive acetic fixative, and some were relaxed in cold water and killed without pressure, those fixed by the latter method being of greatest value for descriptive purposes.

Neodiplostomum pricei may be distinguished from the numerous other species of the genus by the position of the ovary which is posterior and lateral to the anterior testis. In the species which have been described previously the ovary is pretesticular.

The gull, in which the experimental infection was obtained, was hatched and raised in captivity in Washington, D. C. The natural definitive host of the parasite is not known. The life history of this parasite will be given elsewhere.

ZOOLOGY.—*Two new species of* Corophium *from the west coast of America.*[1]

CLARENCE R. SHOEMAKER, U. S. National Museum. (Communicated by MARY J. RATHBUN.)

Recently while sorting amphipod material taken by Dr. Waldo L Schmitt along the coast of Peru in 1926, I noticed an undescribed species of *Corophium* which I here designate as *Corophium baconi*.

In 1927 the Pacific Biological Laboratories sent to the United States National Museum some amphipods from Monterey Bay, California, amongst which was another species new to science which I here designate as *Corophium californianum*.

Corophium baconi, new species

Figure 1

Description of male.—Head with rostrum short and broadly triangular; eye lobes broad, their front margin nearly straight and gradually passing into side margin of head by a broadly rounding curve. Antenna 1, first joint about as long as second plus half of third, lower margin with one distal spine and two about one-third from the proximal end, though the third or proximal

[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 3, 1934.

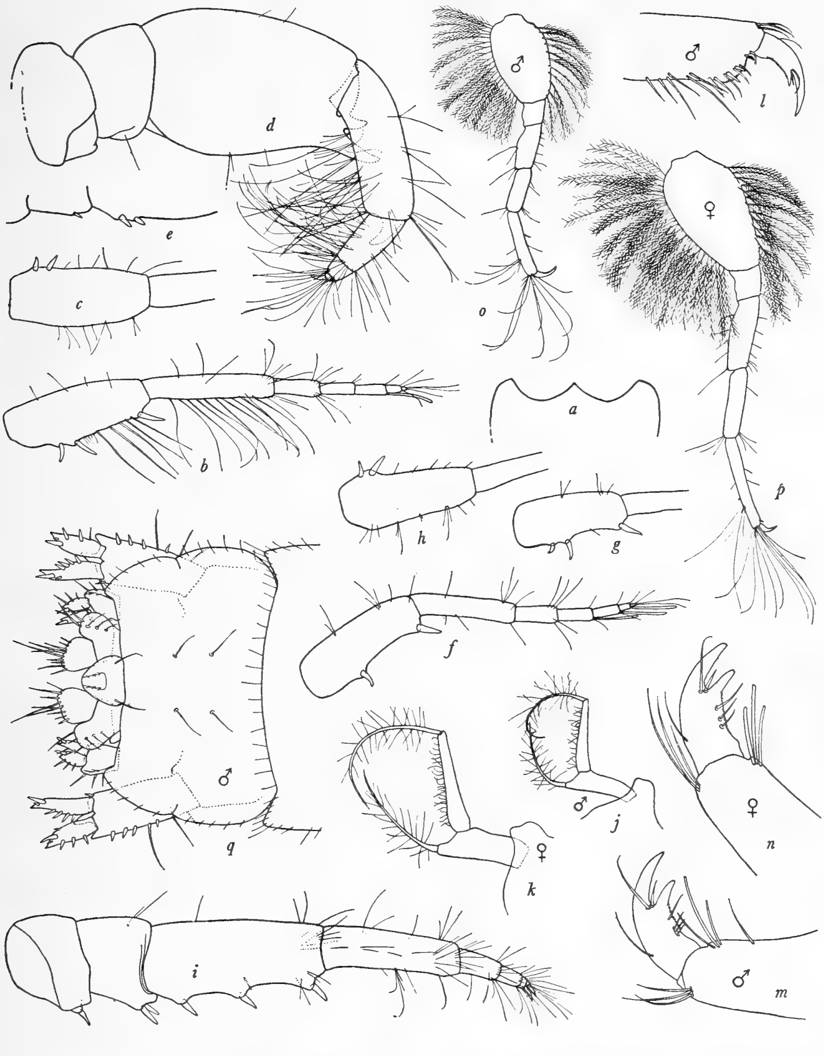

Fig. 1.—*Corophium baconi*, new species. *a*, rostrum and eye lobes, ♂. *b*, antenna 1 ♂, showing lower spines. *c*, antenna 1 ♂, top view. *d*, antenna 2 ♂. *e*, lower margin antenna 2 ♂ showing the two proximal spines. *f*, antenna 1 ♀, showing lower spines. *g*, antenna 1 ♀ showing the occasional third lower spine. *h*, antenna 1 ♀, top view. *i*, antenna 2 ♀. *j*, *k*, mandibular palp ♂ and ♀. *l*, gnathopod 1 ♂. *m*, *n*, gnathopod 2 ♂ and ♀. *o*, *p*, peraeopod 5 ♂ and ♀. *q*, fourth and fifth abdominal segments and their appendages ♂.

spine is usually lacking in younger males, inner or median edge of joint with two spines near proximal end, flagelum with four joints, the last of which is very small. Antenna 2 short and very robust, fourth joint over half as high as long with two lower distal teeth and one or two short spines on lower inner margin not far from the third joint, fifth joint with long, strong tooth very near center of inner side and a long downward-curved tooth on inner side of distal end of joint, lower margin of fifth joint and flagellum provided with

groups of very long setae. Mandibular palp with first joint somewhat produced distally, second joint slightly longer than first. Gnathopod 1, palm oblique and very broadly rounding, very finely serrate throughout and defined by a stout spine, dactyl overlapping palm, and bearing a tooth and fine serrations on inner margin. Dactyl of gnathopod 2 bearing one tooth on inner margin and fine serrations between the tooth and proximal end. Peraeopod 5 with sixth joint shorter than second. Pleon segments 4 to 6 coalesced, but there is a slight marginal depression or notch indicating the division bebetween the fourth and fifth joints. Uropod 2 very short and equal in length to uropod 3, rami equal in length to peduncle and each bearing several long slender spines on outer margin. Uropod 3, peduncle with outer margin produced backward into a broad rounding lobe which is armed distally with three long slender spines and three slender spines arising from the upper surface, ramus not evenly rounding distally but somewhat obliquely truncate and bearing many long slender spines. Telson forming an equilateral triangle with apex evenly rounding, the dorsal surface bearing the usual depression edged with recurved spines, and also bearing a slender seta on either side near the base.

Length.—This is a small species measuring only about 2.5 mm.

Description of female.—The female resembles the male except in the antennae. Antenna 1 usually bearing two spines on lower margin of first joint, but younger specimens may bear a third smaller proximal spine, inner margin with two spines as in the male. Antenna 2, third joint with two spines on lower margin, fourth joint with three evenly-spaced spines on lower margin, and fifth joint without spines on lower margin.

Type.—Male, taken off the coast of Peru, just north of Paita, October 8, 1926, by Dr. Waldo L. Schmitt, while travelling on the Walter Rathbone Bacon Scholarship. Cat. No. 66871 U.S.N.M.

This species is named for Mr. Bacon in whose honor the scholarship was founded.

This species resembles *C. acutum* but differs in the following characters: Antenna 2 in female has no spines on lower margin of fifth joint. There is only one tooth on inner margin of dactyl of gnathopod 2 in either sex. The division between the fourth and fifth pleon segments is indicated by a slight marginal notch whereas in *C. acutum* there is no indication of this division. Uropods 2 and 3 are equal in length, but in *C. a.* uropod 2 is longer than 3.

Besides the specimens taken by Dr. Schmitt off Peru there are in the National Museum collection three male specimens from Venice, southern California, one male from Santa Monica, southern California, collected by Dr. F. C. Clark, and one male from *Albatross* Station 3253, Bering Sea, June 14, 1890.

In one of the males from Venice, which is quite large, there are three proximal spines on the under margin of the first joint of antenna 1 and three spines on median edge. The tooth on the fifth joint of antenna 2 is longer and narrower than in the Peruvian specimens and is situated beyond the center of the joint so that it does not oppose the large terminal tooth of the fourth joint. In the male from Bering Sea there are three spines on the lower margin of first joint of antenna 1. The tooth on the fifth joint of antenna 2 is just slightly on the proximal side of the center, and the inside terminal tooth of

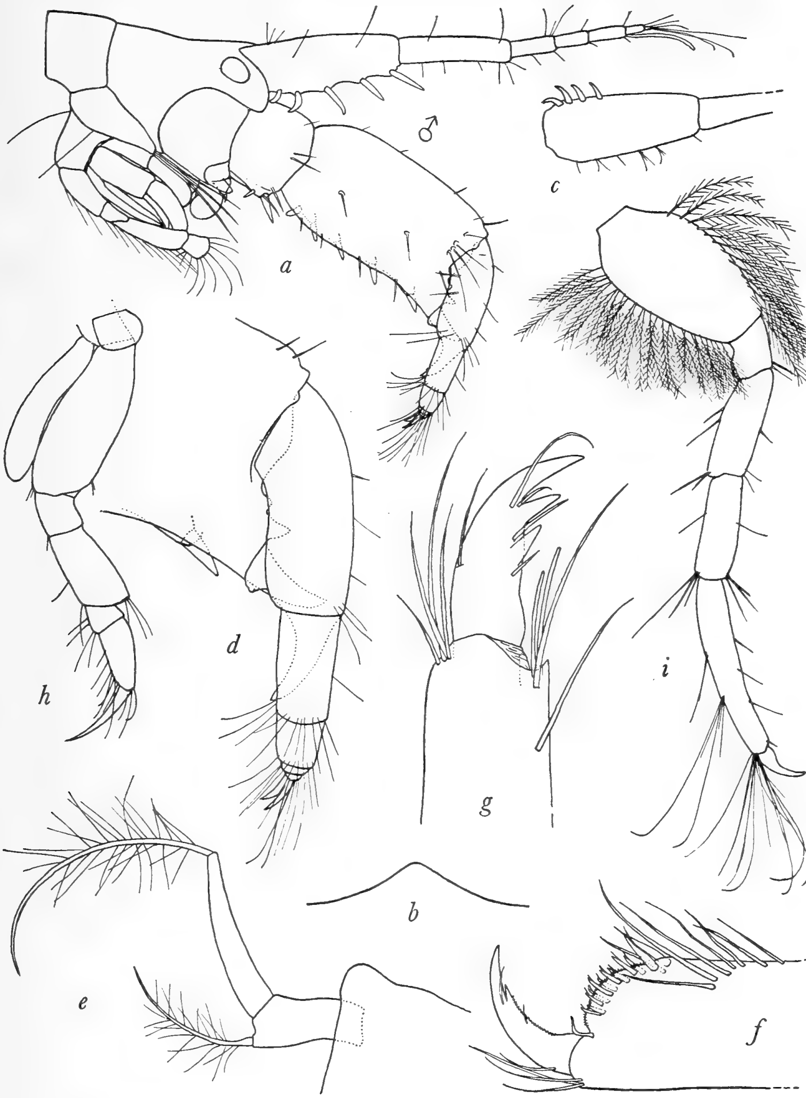

Fig. 2.—*Corophium californianum*, new species, male. *a*, head and antennae. *b*, rostrum. *c*, antenna 1, top view. *d*, antenna 2, greatly enlarged. *e*, mandibular palp. *f*, gnathopod 1. *g*, gnathopod 2. *h*, peraeopod 1. *i*, peraeopod 5.

this joint is short and blunt. The notch on the margin of the pleon indicating the division between the fourth and fifth joints is deeper and more noticeable than in the southern specimens

Corophium californianum, new species

Figure 2

Male.—Rostrum very broadly triangular. Eye-lobes rather long, curved downward and distally rounding. Eyes oval, black. Antenna 1, first joint is

long as second and third combined, armed on lower margin with five spines, and on the inner proximal margin with four spines, flagellum composed of four joints, the last very minute. Antenna 2 rather short for the genus, third joint with two spines on lower margin, fourth joint with a row of five stout spines on lower margin, which is produced distally into a prominent, slightly upward-curved tooth bearing two small teeth on its upper edge, fifth joint very short, not reaching beyond the apex of the distal tooth of the fourth joint, and bearing on lower margin very near the distal end a prominent blunt tooth, the inner distal end of fifth joint produced into a long, pointed, downward-curved tooth which is very nearly half the length of the fifth joint and reaches nearly to the distal end of first antennal joint, flagellum shorter than fifth peduncular joint. First joint of mandibular palp not distally produced. Gnathopod 1, sixth joint not distally expanded, palm rather narrowly and evenly rounding, finely serrate throughout and defined by two stout spines, dactyl slightly overlapping palm and bearing a tooth and fine serrations on inner margin. Gnathopod 2, dactyl bearing two teeth on inner margin. Peraeopod 5, sixth joint equal in length to second. Pleon segments 4 to 6 coalesced and slightly arched from side to side and not bounded laterally by a raised ridge. Telson a little broader than long with apex evenly rounding.

Length.—Male, about 3 mm.

One specimen, the type, taken from holdfast of water-logged kelp dredged in 48 fathoms, in Monterey Bay, California, by the Pacific Biological Laboratories. Cat. No. 66880 U.S.N.M.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1063RD MEETING

The 1063rd meeting was held in the Cosmos Club Auditorium, January 20th, 1934, President DRYDEN presiding.

Program: H. C. DICKINSON: *The mechanism of material prosperity.*—Less than a century ago a British scientist, James Prescott Joule, wrote a paper in which he stated clearly for the first time the fact that heat and work are equivalent to each other, thus establishing what is known as the first law of thermodynamics.

Joule was not the sole discoverer of this "law" but rather was the first one to establish it accurately among many scientists who were approaching the same solution from various points of view.

About 50 years ago another scientist, J. Willard Gibbs, professor at Yale University, was the first to formulate accurately the second law of thermodynamics. Gibb's work was translated into German and not until 15 years later did Americans know its worth after German scientists had appreciated what it meant in the field of science.

Thus was laid the foundation for the modern science of thermodynamics which is the foundation of the world's present growth in the production of power with all that this means in comfort and plenty.

Thermodynamics is a statistical science and men have long known that its basic laws must apply in other fields. National or world economics presents statistical problems which are in some ways similar to those of thermo-

dynamics. However, few economists are familiar with the natural sciences, and few physicists and engineers have been interested in economics, so there has been heretofore little chance of bridging the gap between the two sciences.

In the last few years, however, the economic convulsion of the world has turned the attention of many students of the natural sciences to economic questions. Thus, as 100 years ago, so now is there a wave of thought focused, this time not on *heat and work* but on *work and money*. Out of this thought there has emerged a new science to which we have given the name of *econodynamics*, a study of the basic laws of economics or, more specifically, of the relationship between *work and money*.

Some of the similarities between the science of thermodynamics and the newer one of econodynamics are striking. One starts out in each case with "conservation." Conservation of matter and of energy are well known laws of nature. "Conservation of money" parallels them.

The last is, however, more complex; matter and energy are fixed by nature, money by men. But it turns out that man must fix money so that the law of conservation holds, or else the money is no longer *good money*.

Similar comparisons hold for the first and second laws of thermodynamics. The second law of econodynamics states that in any economic system (nation or world) in which men are free to spend their money, it is impossible continuously to maintain any price above the normal competitive level without supplying money or work from outside the system.

The "law of supply and demand" defines what may be termed an econodynamic potential, showing in which direction price will move when either or both are changed.

To illustrate some of the subject matter of econodynamics, there has been designed and constructed a mechanical model known as an *economostrator*. It was devised purely as a means of visualizing the ideas of scientists, engineers, and others who have applied this new type of scientific analysis to economic problems during the past several years. It has proved illuminating, even to those who are familiar with the entire process.

The whole economic problem can be summed up in a few words. There are three essentials in the problem like pressure, volume and temperature for a gas, or current, voltage and resistance for electricity. These are *payrolls*, *capital*, and *debts*. There is a certain optimum relationship between them which yields a maximum net national income and no one of them can be increased beyond this point without decreasing the net income and shortly decreasing all three elements as the entire system starts downhill.

Almost the only new element in the analysis is the fact, seemingly shown now for the first time, that this optimum relationship is unstable. When the system starts out of balance the result is to increase this unbalance. The system, as it is depicted by the economonstrator, is such that a small surplus of savings must always go into capital and debts or else prosperity will decline through depletion of capital. If this surplus is allowed to continue, however, the system will be unbalanced in the other direction and prosperity will decline through an overburden of interest on debts.

In the ordinary case of business cycles this unbalance goes only about so far and corrective forces bring it back through the wiping out of the surplus savings which have gone into capital and debts. However, if the corrective forces which are mainly failures, defaults and foreclosures, do not go far enough, then the main instability of the system becomes apparent and the whole gradually collapses. Once these factors are recognized, business cycles

and national declines can be put under control by simple processes which have been worked out in some detail.

If both short cycles and economic declines were prevented, it may be seen that nearly all the serious faults of the capitalistic system would vanish. The main cause of international friction and war would disappear in the same way, as would unemployment and poverty; except that no one can ever expect to have more than he can produce unless some one else gives it to him. (*Author's abstract.*)

The following informal communication was presented.

F. G. BRICKWEDDE: The vapor pressure of a sample of nearly pure molecular deuterium in its solid and liquid states was compared with the vapor pressure of ordinary hydrogen. The following table is a brief of the results:

T	The Vapor Pressures of Ordinary Hydrogen	Deuterium	
20.38°K	76.0 cm. of Hg	26.	Boiling Point of Ordinary Hydrogen
18.6	42.9	12.	Triple Point of Deuterium
14.0	5.4	0.5	Triple Point of Ordinary Hydrogen

(*Author's abstract.*)

1064TH MEETING

The 1064th meeting was held in the Cosmos Club Auditorium, Saturday, February 3rd, 1934, President DRYDEN presiding.

Program: P. R. HEYL: *The composition of harmonic motions.*—All cases of composition of harmonic motions may be divided into two classes on the basis of energy considerations, designated respectively as conservative and non-conservative.

To the first class belong sound and light waves; to the second, alternating electric currents and tidal phenomena. In the conservative class the energy of the resultant must be equal to the sum of the energies of the constituents; in the non-conservative class this is not the case.

The conservative class may again be divided into two groups. In the first group the component running waves move in opposite directions; in the second, they move in the same direction.

The principle of superposition of amplitudes, applied to the case of oppositely running waves, gives results consistent with the principle of the conservation of energy; but applied to the case of similarly running waves gives rise to a contradiction. In such cases composition must take place by addition, not of amplitudes, but of energies. (*Author's abstract.*)

Discussed by Messrs. DRYDEN, GISH, TUCKERMAN, CURTIS, HUMPHREYS, DICKINSON, and HAWKESWORTH.

H. A. MARMER: *Tides that follow the sun.*—At most places the tide follows the moon in coming later each day by about fifty minutes on the average. On the basis of gravitation, this finds explanation in the fact that the tide-producing power of a heavenly body varies directly as its mass and inversely as the cube of its distance from the earth. Hence the moon plays the leading role in bringing about the tide.

There are some places, however, at which the tide appears to follow the sun rather than the moon. Tahiti in the Society Islands and Tuesday Island in Torres Strait are examples. At these places high and low water do not come later each day by fifty minutes on the average; instead, the tide comes at about the same time day after day. Such tides are therefore primarily solar tides.

The existence of solar tides is explained in entirely different ways by each of the two theories that have been proposed for the mechanism of the tides on our earth. The progressive-wave theory—the older—regards the tides of the open ocean as progressive waves which are derived from the primary tide waves of the Southern Ocean. Solar tides according to this theory occur at places where two progressive waves meet under the condition that they have approximately equal ranges, but differ six hours in time. Under such conditions the lunar high water of one wave is neutralized by the lunar low water of the other, and thus permits the solar constituent to become the predominant constituent. Tides at such places therefore present the features of solar tides.

The more recent theory of the tide, known as the stationary-wave theory, conceives the response of the ocean waters to the tide-producing forces to consist of stationary-waves, rather than progressive waves. According to this theory the dominant tides of the world arise from stationary-wave oscillations which are set up and maintained in various portions of the oceans by the periodic tide-producing forces of sun and moon. And since the periods of these forces differ, different portions of the oceans will respond in different ways, on account of resonance. In other words the axis of oscillation of an oceanic system responding to the solar forces will not necessarily coincide with the axis of a lunar oscillating system.

On this latter theory, therefore, solar tides in the open sea are explained as occurring in regions which lie near the axis of a lunar oscillating system, but at some distance from the axis of a solar oscillating system. The rise and fall of the lunar constituent at such places is small, and this gives the solar constituent the opportunity to become the dominant constituent of the tide. (*Author's abstract.*)

Discussed by Messrs. LIFEROCK, TUCKERMAN, HAWKESWORTH, BITTINGER, HULBURT, HUMPHREYS, MCNISH, and HEYL.

1065TH MEETING

The 1065th meeting was held in the Cosmos Club Auditorium, Saturday, February 17th, 1934, President DRYDEN presiding.

Program: R. J. SEEGAR: *The physical nature of the chemical bond.*—The speaker reviewed the historical development of our ideas concerning the nature of the covalent chemical bond and presented the mathematical theory of the Quantum Mechanics used in the calculations of the energy of two atoms held together by such a bond. (*Secretary's abstract.*)

Discussed by Messrs. DRYDEN, HAWKESWORTH, GIBSON, MAXWELL, HUMPHREYS, TUCKERMAN, and HAFSTAD.

1066TH MEETING

The 1066th meeting was held jointly with the Washington Academy of Sciences, in the Cosmos Club Auditorium, Saturday, March the 3rd, 1934. L. B. TUCKERMAN, president of the Academy presided.

The program consisted of an address entitled *Remarks on catalysis* by James Franck, formerly director of the Second Physical Institute at the University of Göttingen.

The abstract of this address will be published in the PROCEEDINGS OF THE ACADEMY.

Discussed by Messrs. MOHLER, WULF, HUMPHREYS, TUCKERMAN, L. H. ADAMS, and R. E. GIBSON.

1067TH MEETING

The 1067th meeting was held in the Cosmos Club Auditorium, Saturday, March 17th, 1934, President DRYDEN presiding.

The program consisted of an address by J. H. TAYLOR: *The process of generalization in mathematics as exhibited in the development of the Frenet formulae.*—Beginning with elementary considerations of the representation of points and directions in a three dimensional space, transformations of coordinate systems and the correspondence of points and directions were discussed, and the Frenet Formulae then developed. The three dimensional case was generalized, and the same procedure carried through for an n-dimensional space representing n-variable quantities or properties, and the more general, Frenet formulae for an n-dimensional space were derived. (*Secretary's abstract.*)

Discussed by Messrs. DRYDEN, HAWKESWORTH, DANTZIG, TUCKERMAN, MUNK, HOPPMAN, HUMPHREYS, SEEGAR, BLAKE, GIBSON, and SEARLES.

1068TH MEETING

The 1068th meeting was held in the auditorium of the Cosmos Club, March 31, 1934, President DRYDEN presiding.

The program consisted of the fourth Joseph Henry Lecture. This was given by Professor OSWALD VEBLEN of Princeton University, on the subject of *Spinors.*

This lecture has been published in full in this JOURNAL **21**: 281. 1934.

Discussed by Messrs. HAWKESWORTH, TUCKERMAN, DANTZIG, ADAMS, SEEGAR, BRIGGS, and GISH.

1069TH MEETING

The 1069th meeting was held in the Cosmos Club Auditorium, April 14, 1934, President DRYDEN presiding.

Program: J. W. MCBURNEY: *The indentation of asphalt tile.*—A formula was presented for relating the depth of indentation to the time during which a loaded sphere acts upon such a plastic body as an asphalt tile. Data were presented showing the effect of varying the diameter of the sphere and the load. A portable instrument for indentation testing was described. The use of these test methods in technical specifications for asphalt tile was discussed. (*Author's abstract.*)

Discussed by Messrs. DRYDEN, BRIGGS, LEDIG, and GISH.

W. G. BROMBACHER: *Altitude in airplane and balloon flight.*—In making an international record for altitude in airplane and balloon flights the lowest pressure attained is measured and not the altitude. This pressure is probably the best simple measure of the performance of the airplane in view of the fact that the air temperature varies but little at the altitudes now necessary to break the unlimited record for altitude. The lowest pressure is converted to altitude by means of the altitude-pressure relation of the F. A. I. standard atmosphere which has been adopted internationally for such use.

A barograph is used to secure a record of air pressure against time. It is mounted in the aircraft from an elastic suspension. The trace is made by a stylus operating on a smoked chart of paper or aluminum sheet. Many barographs contain an element for recording the instrument temperature.

In this country the barograph is tested at the Bureau of Standards. The test consists essentially in subjecting the barograph to a flight history test, during which the conditions of the flight as to instrument temperature and

air pressure are reproduced. The lowest indicated pressure is measured by a mercurial barometer of the altitude type.

Details of record breaking flights are given in the following tables:

AIRPLANE FLIGHTS TO HIGHEST ALTITUDE

PILOT	COUNTRY	DATE	LOWEST PRESSURE	CORRESPONDING FAI ALTITUDE
			mm. Hg.	Feet
J. A. Macready	U. S.	Sept. 28, 1921	178	34563
S. Lecointe	France	Oct. 30, 1923	161.5	36555
J. A. Macready	U. S.	Jan. 29, 1926	146	38704
C. C. Champion	U. S.	July 25, 1927	147.5	38491
St. C. Streett and A. W. Stevens	U. S.	Oct. 10, 1928	152	37854[1]
A. Soucek	U. S.	May 8, 1929	143	39140
W. Neuenhofen	Germany	May 25, 1929	126	41794
A. Soucek	U. S.	June 4, 1930	118	43166
C. F. Unwins	England	Sept. 16, 1932	113.5	43976
G. Lemoine	France	Sept. 28, 1933	109	44822

[1] By barometric formula from pressure and temperature observations 39606 feet. By camera method 39250 feet.

SEAPLANE FLIGHTS TO HIGHEST ALTITUDE

PILOT	COUNTRY	DATE	LOWEST PRESSURE	CORRESPONDING FAI ALTITUDE
			mm. Hg	Feet
S. Lecointe	France	March 11, 1924	225	29462
V. Demougeot	France	March 28, 1927	215	30479
C. C. Champion	U. S.	July 4, 1927	151	37995
A. Soucek	U. S.	June 4, 1929	147	38560

BALLOON FLIGHTS TO HIGHEST ALTITUDE

(OPEN GONDOLA)

PILOTS	COUNTRY	DATE	LOWEST PRESSURE	CORRESPONDING FAI ALTITUDE
			mm. Hg	Feet
Suring and Berson	Germany	July 31, 1901	170.5(?)	35424 (10800 m.)
H. C. Gray	U. S.	March 9, 1927	235	28510
H. C. Gray	U. S.	May 4, 1927	122	42470[1]
H. C. Gray	U. S.	Nov. 4, 1927	122	42470[2]

[1] Not recognized as a record because Capt. Gray jumped from balloon before landing.

[2] Not recognized as a record. Capt. Gray was found dead in the gondola and it was therefore presumed that he did not navigate the balloon to a landing.

STRATOSPHERE BALLOON FLIGHTS

PILOTS	COUNTRY	DATE	VOLUME OF BALLOON	LOWEST PRESSURE	CORRESPONDING FAI ALTITUDE
			Cu. ft.	mm. Hg	Feet
Piccard and Kipfer	Belgium	May 27, 1931	141,000	78	51775
Piccard and Cosyns	Belgium	Aug. 18, 1932	500,000	73	53153
Prokovieff, Birnbaum and Godounoff	Russia	Sept. 30, 1933	860,000	49–50	62300(?)
Settle and Fordney	U. S.	Nov. 20, 1933	600,000	49.5	61237
Fedossenko, Vasenko, Usiskin	Russia	Jan. 30, 1934	882,850	—	72178(?)

(*Author's abstract.*)

Discussed by Messrs. DRYDEN, STIMSON, DICKINSON, HAWKESWORTH, and LEDIG.

1070TH MEETING

The 1070th meeting was held in the Cosmos Club Auditorium, May 12, 1934, President DRYDEN presiding.

The program for the evening consisted of an address, *The thunderstorm and its electrical effects*, by B. F. J. SCHONLAND of the De Beers Institute of Physics and Mathematics, University of Cape Town, South Africa.

Little progress has been made in the study of thunderstorm electricity until it was placed on a quantitative basis by Prof. C. T. R. Wilson and his school in 1919. The recent measurements of the electric moment of lightning discharges give average values of about 80 coulomb-kilometers for this quantity. It follows that the charge destroyed by a flash is of the order of 20 coulombs. It can then be deduced without ambiguity that the potential difference developed by the average thundercloud is some billions of volts and that the continuous rate of generation of electrical energy is about 3×10^6 kilowatts. Approximately half of this is spent in the form of lightning, the remainder being devoted to the supply of dissipation or leakage currents above and below the cloud. These currents are of considerable importance in that they appear to feed a positive charge from earth to upper atmosphere and thus to provide a satisfactory mechanism for the maintenance of the permanent electric field which prevails all over the earth in fine weather.

In the discussion of the genesis of these currents—point discharge from the earth and cumulative ionization in the upper air—certain interesting deductions emerge. Thus the space charge above the earth makes it difficult for the field at the earth's surface to reach values required for the initiation of a lightning discharge. Again the thunderstorm should, as Prof. Wilson has pointed out, be capable of producing considerable additional ionization in the Kennelly-Heaviside layer. Experimental evidence on these questions supports the deductions made. The thunderstorm origin of most atmospherics

and the application of this knowledge were briefly dealt with, together with the experimental evidence for the production by thunderclouds of an upward-moving spray of penetrating electrons.

The preliminaries to the lightning discharge have recently been studied photographically by a Committee of the South African Institute of Electrical Engineers. The discharges examined have so far all been from a negative cloud pole to the ground, the most frequent case. They reveal the presence of downward electron moving avalanches and will, it is hoped, enable the mode of progression of such avalanches to be studied in detail on a large scale. (*Author's abstract.*)

Discussed by Messrs. GISH, MOHLER, SILSBEE, WHITE, HUMPHREYS, GIBSON, TUCKERMAN, and BRICKWEDDE.

F. G. BRICKWEDDE, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

National Bureau of Standards.—Dr. LYMAN J. BRIGGS, Director of the National Bureau of Standards, left Washington on July 6 for the balloon camp near Rapid City, South Dakota, to witness the stratosphere flight under the auspices of the National Geographic Society and the U.S. Army Air Corps. Dr. BRIGGS is chairman of the Advisory Committee for the Flight, appointed by President GROSVENOR of the National Geographic Society. He has given a great deal of time to the plans for the flight, particularly in connection with the scientific instruments carried.

Dr. H. J. MCNICHOLAS has returned to his former work in the organic and fibrous materials division on X-ray investigations of the structure of fibers from farm waste.

Dr. J. H. DELLINGER, chief of the radio section, has enlisted the cooperation of owners of short-wave radio sets, in a world-wide investigation to discover the origin of long-delay radio echoes. Two high-power high-frequency stations are transmitting special signals to facilitate observations. They are GSB, Daventry, England, and HBL, the League of Nations station in Geneva, Switzerland. GSB transmits a 1,000-cycle note on a frequency of 9510 kilocycles each Sunday, Tuesday and Thursday, from 3:25 to 3:55 A.M., Eastern Standard Time and HBL transmits on 6675 kilocycles each Sunday, Wednesday and Friday from 6:00 to 6:30 A.M. EST. The familiar round-the-world echo occurs one-seventh of a second after the original signal, the time required for the wireless wave to circle the earth. The long-delay echoes being studied may occur as much as three seconds after the primary signal.

An investigation of the paper used for Braille books for the blind has resulted in the discovery that use of paper with a maximum tensile strength produces Braille dots that stand up during a long life and do not crack and irritate sensitive finger tips of blind readers.

Bureau of Biological Survey.—Changes in the Wildlife Bureau, including the consolidation of the Divisions of Game and Bird Conservation and Predatory Animal and Rodent Control, and establishment of a Migratory Waterfowl Division and Public Relations Unit, have been announced.

Public Health Service.—Headed by Dr. JAMES P. LEAKE, veteran of the Service, a party of investigators including Drs. E. T. CEDER, A. G. GILLIAM and W. P. DEARING has left for California to lend their aid in the great battle against infantile paralysis being waged in that state.

For over a year Dr. W. T. HARRISON of the U.S. Public Health Service has been working on a vaccine to give protection against infantile paralysis. He has already had "encouraging" results in protecting monkeys with the vaccine, but he is not yet ready to try it on humans. The vaccine is made by a special technic which officials of the U.S. Public Health Service are not willing to report at present.

Weather Bureau.—Beginning in July, the U.S. Weather Bureau will make routine weather observations by airplane on a much larger scale than heretofore practiced. From twenty different airports, pilots will make observation flights to high altitudes, carrying a meteorograph which automatically records humidity, temperature, and pressure.

NEWS BRIEFS

Giant map-making camera.—The world's largest camera, 31 feet long and weighing fourteen tons, has just been placed in operation reproducing nautical charts and airway maps. So precise is the work of this huge camera, which resembles a railway trestle in structure, that cork pads and other vibration-damping provisions must be used to eliminate the slightest building tremors, although it has been installed directly on the foundations of the new Department of Commerce building.

Capt. R. S. PATTON, director of the U.S. Coast and Geodetic Survey, states that this gigantic instrument will make it possible to photograph a complete chart on one negative, with a probable error of not more than two-thousandths of an inch. Two years were devoted to its design, construction and adjustment, at a total cost of over $15,000.

In order to obtain the greatest accuracy possible, every available source of information was consulted from the designs of commercial copying cameras to reports of technical experts at the National Bureau of Standards. The preliminary designs were prepared at the Sight Shop of the Naval Gun Factory.

Shrink fits with "dry ice."—Solid carbon dioxide, popularly named "dry ice," may, at its temperature of −112 degrees Fahrenheit compete with heat in securing shrink fits for machine parts. W. H. SWANGER of the National Bureau of Standards, reports that machine shop practice may come to accept the new method of applying low temperature instead of heat in shrinking metals. When it is necessary to secure a metal band to a shaft, the usual practice is to heat the band. Expansion allows it to be slipped into place, and as it cools it contracts to a tight fit. However, by "refrigerating" the inside part, or shaft, it can be shrunk materially. The band is slipped on and when the shaft warms to room temperature it expands again to normal size, and a tighter fit is secured.

PERSONAL ITEMS

Dr. DAVID WHITE, eminent scientist of the U.S. Geological Survey, was awarded the Boverton Redwood medal by the Institution of Petroleum Technologists in London. This is the first time that the medal, highest award of the institution, has been given to an American and only the second time it has gone to a scientist outside the British Empire.

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JOURNAL
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VOL. 24 SEPTEMBER 15, 1934 No. 9

PHARMACOLOGY.—*Remedies for cyanide poisoning in sheep and cattle.*[1] A. B. CLAWSON, H. BUNYEA, and JAMES F. COUCH, Bureau of Animal Industry.

The treatment of cyanide or prussic acid poisoning is an important problem to the veterinarian. Many cases of poisoning occur each year as a result of livestock feeding on cyanogenetic plants such as wild cherry, sorghum, arrow grass, and the like. Those plants that are capable of developing dangerous quantities of hydrocyanic acid under favorable circumstances are widely distributed and the problem of treating cyanide poisoning is not confined to a few localities, but is a matter of national interest.

Recent reports of the beneficial results following the use of new remedies in cases of this kind have provoked considerable interest as to their applicability to treatment under practical conditions. As most of the information available with respect to these remedies has been obtained from experiments on laboratory animals it was considered desirable to secure data concerning their effectiveness with larger animals. This paper reports the results obtained in the first two series of experiments in which sheep and bovines were the species used.

The experimental animals used had been kept under observation at the Experiment Station of the Bureau of Animal Industry, Bethesda, Md., for a sufficient period to establish knowledge of their healthy condition. Some of the animals had been used previously in other experiments, but at the time of these studies were normal. Except No. 1299, all of the sheep had been used in either anthrax or blackleg immunity tests and certain of the cows had been the objects of mastitis studies.

The remedies used had previously been the subject of studies by other workers in this field. Lang (8) in 1895 studied the antidotal

[1] Received May 8, 1934.

action of sodium thiosulphate and other sulphur compounds in dogs and rabbits and found the first-named salt the most effective. His results showed that there is a great variation in effectiveness when the method of administration of the poison and antidote are varied. Hug (5), Turner and Hulpieu (11), and Forst (4) reported antidotal properties in sodium thiosulphate, but Hug considered it less effective than either methylene blue or sodium nitrite. The sodium thiosulphate used in our experiments was analytical reagent grade and was tested for identity and purity.

Methylene blue was found to be an antagonist of hydrocyanic acid in white mice by Sahlin (9) in 1926. Confirmation was obtained in the work of Eddy (3) on dogs and there has since been a large number of reports on the remedial value of that substance. Trautman (10) as a result of an extensive study of methylene blue as an antidote to gaseous hydrocyanic acid poisoning in mice, guinea pigs, and rabbits reports: "The average of results indicated no advantage in favor of the treated animals." Hug (5, p. 519) found methylene blue less effective than sodium nitrite. The methylene blue used in our experiments was the medicinal grade tested for identity and purity.

Sodium nitrite was proposed by Hug (5, p. 89) in 1932, who found it superior to methylene blue and sodium thiosulphate in dogs and rabbits. This salt has been used with considerable success in experimental cyanide poisoning of sheep and cattle by Fitch and his coworkers (personal communication) in Minnesota. Hug and Wendel (12) independently conclude that the mode of action of sodium nitrite is to convert part of the hemoglobin of the blood into methemoglobin, which then combines with the cyanide and forms a relatively nontoxic compound. In support of this hypothesis both investigators have demonstrated that methemoglobin itself acts as an antidote in cyanide poisoning. The sodium nitrite used in our study was of analytical reagent grade tested for identity and purity. The solutions used were freshly prepared for each experiment.

Sodium tetrathionate was found by Chistoni and Foresti (1) to protect against doses of potassium cyanide not much in excess of the m.l.d. Draize (2) found it more effective than methylene blue. The sample used by us was prepared according to the method of Klobukoff (7).

The use of a combination of sodium thiosulphate and sodium nitrite was suggested by the knowledge that these substances are thought to counteract the poisonous effects of cyanides in different ways, the nitrite through methemoglobin formation and the thio-

sulphate by converting the cyanide into thiocyanate. Since the quantity of hemoglobin that can safely be converted into methemoglobin for antidotal purposes is strictly limited by the minimal quantity of hemoglobin that is necessary to carry out the normal transportation of oxygen to the tissues, there is an upper limit to the dose of nitrite that can be administered with safety. Sodium thiosulphate, which does not convert hemoglobin into methemoglobin, and which does not react chemically with sodium nitrite, would serve to increase the effectiveness of the antidote without increasing its toxicity. After several experiments had been made on bovines and had demonstrated the superiority of the combination of remedies a paper by Hug (6, p. 711) was received in which, working with rabbits and dogs, he clearly demonstrated the effectiveness of the combination.[2]

For the purposes of the experiments reported in this paper the cyanide was given in the form of a freshly prepared solution of potassium cyanide. The specimen of salt used was of analytical reagent quality and analysis showed it to contain 98.12 per cent KCN. The cyanide was given by drench and the remedies given by intravenous or intraperitoneal injection except in two instances.

SYMPTOMS OF POTASSIUM CYANIDE POISONING

The symptoms of hydrocyanic acid poisoning have been described in various publications dealing with poisons, materia medica, and other subjects. The series of experiments carried out by the writers has furnished some detailed information regarding the sequence of the different symptoms, which it seems advisable to point out.

It is well known that an appreciable time elapses between the giving of potassium cyanide and the appearance of perceptible symptoms. In the cases which form the basis for this paper, this time did not differ particularly with the two classes of animals. For the cattle, the time varied from 0.5 minute to 2.5 minutes, and averaged 1.1 minutes. The longest time was for an animal given a small dose and which was given the material in the shortest time. With the sheep the time varied between 0.5 minute and 2 minutes, and averaged 1.5 minutes.

In the different experiments, from 0.5 minute to 2 minutes were required to give the drench. The elapsed time between giving of the

[2] Since this paper was prepared a report by Chen, Rose, and Clowes (Proc. Soc. Exp. Biol. Med. **31**: 250. 1933) has been received in which these authors show that the combination is very effective against potassium cyanide poisoning in dogs.

potassium cyanide and the appearance of symptoms was taken from the completion of the drenching.

In practically all cases the first indication of symptoms was an acceleration in rate and an increase in the depth of the respiration. In some instances, at the same time the animal appeared to be anxious as though apprehensive that something was not quite right.

In very mild cases, even when nothing was given to counteract the poison, the effect disappeared within a few minutes. Three poisoned cattle appeared to have entirely recovered within seven minutes after the cyanide was given. In two cases, a somewhat accelerated and unusually deep respiration and a somewhat increased pulse rate were all that were abnormal. The third cow, in addition, became very nervous, hypersensitive to movements, sounds, or other stimuli, and her pupils were considerably dilated. She also showed a slight leg weakness and appeared to be frightened. Two sheep, given small doses, apparently were entirely recovered in three and five minutes, respectively, after being given the cyanide. In the latter case, the pulse became very fast and there was slight spasmodic jerking of the muscles of the shoulders. The doses of hydrocyanic acid given these animals varied from 0.441 to 1.102 milligrams per kilogram of body weight. The smaller dose caused only a slight increase in the pulse rate of a cow.

When more seriously poisoned the rate and depth of the respiration rapidly increased and frequently culminated in spasms and dyspnoea. In one cow, spasms developed in nine minutes. In the other cattle spasms developed in five of the eleven cases and appeared in from 1.5 to 5 minutes, or an average of three minutes after the cyanide was given. With the exception of one case in which the notes are not definite, all the cases which did not have spasms were either light cases and recovered, or were given remedial treatment. In the one untreated fatal cattle case in which spasms developed, the spasms occurred at intervals for eleven minutes.

In the sheep, spasms of greater or less intensity developed in 22 of the 37 cases of poisoning. They occurred in from 1 to 14 minutes after the cyanide was given, or in an average time of $4\frac{1}{4}$ minutes. In some instances the duration was very short, consisting of a few spasmodic contractions. In some, they lasted for 7 to 9 minutes, while one animal had spasms which occurred at intervals for 51 minutes. Aside from two cases of the kind, the average duration was approximately $2\frac{1}{2}$ minutes.

The spasms varied considerably, some consisting of more or less violent kicking, and some opisthotonos, while in other cases there were violent tetanic contractions of the legs and body muscles, these usually being accompanied with jerky movements of the eye balls or rolling of the eye ball downward. At this stage, in the cattle cases, the jugular vein was very prominent and evidently engorged with blood. This, together with the blanching of the teats, would appear to indicate a contraction of the peripheral capillaries. During this period the venous blood was a bright red in color.

At approximately the same time that spasms developed, the respiration became labored or dyspnoeic and much slower than during the period of stimulation. As experimental treatments were given many of the poisoned animals during the period of spasms or very shortly thereafter, these animals can not be used in considering the progressive changes that occurred after that time. Only one untreated cow showed evidence of dyspnoea. This lasted for 43 minutes, or up to about two minutes before the animal died.

In six sheep which recovered, the period of dyspnoea lasted for from one to three minutes following which the respiration became easier and the animal gradually improved. In eight fatal cases, the dyspnoea lasted for from 11 to 38 minutes, or an average of 17 minutes. In other words, when dyspnoea continued for more than three minutes, the animals usually died. One sheep was an exception. On two occasions, this animal had several repeated periods of weakness, spasmodic muscular jerking, trembling and mild dyspnoea. These occurred during periods of 1 hour and 20 minutes on the first occasion and 1 hour on the second. The sheep recovered from both cases of poisoning.

During the period of dyspnoea the respiration varied greatly in rate. At times, it resembled panting, and at other times it was very deep, irregular and the expiration very much forced, while in other cases the animals were gasping for breath. In some cases it was more or less intermittent, being held for several seconds at a time. In mild cases the panting or labored respiration became less and less pronounced and then the animals passed into a recovery period. In fatal cases, it grew less deep and the periods between respiratory movements usually increased in length until the breathing ceased altogether. During this period the membranes were usually more or less cyanotic and the blood as seen in the eye veins, dark in color.

The period of dyspnoea was practically coincident with a severe

weakness and depression, the animal being stretched out on one side. The eye reflex when noted was apparently normal and the animal usually kicked occasionally, or there was some trembling of the surface muscles. Considerable blood and watery liquid came from the nostrils and mouth of two of the cattle during this period. Both animals died.

The period of recovery in the two cattle given light doses was very short. Within 7 minutes in one case, and 10 minutes in another, after the cyanide was given, the animals appeared to have entirely recovered. Both were mild cases of poisoning. Some of the poisoned sheep recovered within a few minutes, while others were ill from 30 minutes to a few hours, depending on the severity of the poisoning. For all the sheep that recovered without the use of remedial treatment, the period of illness varied from four minutes to something more than $2\frac{1}{4}$ hours. The exact duration in the longer cases is not definitely known. In one fatal cattle case which did not receive any remedial measure, the animal was sick for 42 minutes. The sheep died after from 11 to 55 minutes of illness, the average time for the cases in which the notes are definite being 33 minutes.

LESIONS IN THE CATTLE

Autopsies were made on four of the five cattle that were fatally poisoned. None of the sheep were autopsied. In all the cattle the blood and the muscle tissues were very dark red in color. On being allowed to stand exposed to the air the blood, especially, soon became a bright red and resembled arterial blood. The lungs of one of the animals, No. 1267, were very severely congested and edematous. A considerably quantity of bloody and frothy liquid flowed from the mouth of this animal while it was in the latter stages of its illness. This apparently came from the lungs. The lungs of two of the other animals, Nos. 1264 and 1266, contained somewhat more blood than is usually present in normal cattle. This was not sufficient to call congestion however. Some bloody liquid flowed from the mouth of one of these animals, No. 1264, just before death. In the trachea of No. 1265, between the longitudinal folds of the mucosa, there were prominent hemorrhages which extended a short distance into the bronchial tubes. Petechiae were similarly present in the tracheal mucosa of No. 1267. This was the animal with the severely congested lungs. Aside from a few petechiae on the surface of the ventricles of No. 1264 and a slightly congested mucosa of the 4th stomach of No. 1267, the other tissues appeared to be normal.

TABLE 1.—Doses, Calculated as Hydrocyanic Acid, Given to Sheep and the Effects Produced when no Remedies were Used

Date	Animal No.	Dose given mg/kg and effect				
		No effect	Symptoms	Sick	Very sick	Death
1933 Oct. 3	1308					4.410
" 6	1315					3.307
" 10	1313					3.307
" 2	1303					2.646
" 2	1302					2.425
" 10	1310				2.425	
" 2	1307					2.315
" 2	1301					2.135
" 10	1313			2.315		
" 10	1300			2.315		
" 6	1310				2.205	
" 2	1300				2.205	
" 2	1306			2.205		
" 5	1310			2.092		
" 3	1312					1.764
" 5	1314		1.764			
" 6	1313		1.543			
" 5	1313		1.543			
" 3	1414		1.323			
" 5	1300		1.102			
Nov. 10	1299		0.992			
Oct. 3	1313	0.882				

TOXIC AND LETHAL DOSES OF HYDROCYANIC ACID FOR SHEEP AND CATTLE

In order to establish a basis on which to judge of the efficacy of remedial measures, various quantities of potassium cyanide were given and the subsequent effects allowed to take their natural course unmodified by remedies of any kind. The doses which were figured as milligrams of HCN per kilogram of the animal's body weight varied from 0.882 milligram to 4.41 milligrams per kilogram. The various doses as given to sheep are shown in Table 1, and those to cattle in Table 2. As shown in the tables the cases of poisoning were grouped into classes on the basis of the severity of the illness. The degree of illness is indicated by the terms "symptoms," "sick," "very sick," and "death." Among those classed as showing "symptoms" were included cases in which the respiration was distinctly stimulated and in which evidence of uneasiness or weakness developed. These animals were able to remain on their feet. The "sick" animals developed marked dyspnoea, and in some cases opisthotonos or mild spasms. They became too weak to stand throughout the illness, but did not lie stretched out on their sides. Those animals which went into a coma, developed pronounced spasms, or were lying stretched out on one side in a more or less comatose condition for some minutes are classed as "very sick."

The various doses given to sheep and the severity of illness of each case are shown in Table 1.

The results establish, fairly closely, the minimum toxic and lethal doses for sheep, when the cyanide is given as a drench and under the conditions accompanying these experiments. As symptoms were produced by 0.992 milligram per kilogram of animal weight calculated as hydrocyanic acid, and by all larger doses, and as 0.882 milligram was without apparent effect, 0.992 can be taken as close to the minimum toxic dose.

In one case, 1.764 milligrams per kilogram killed. In comparison the same dosage in another case produced only symptoms and in other cases sheep survived doses as high as 2.424 milligrams per kilogram. The small dose of 1.764 on the basis of other results appears erratic and may indicate an error. Two sheep were fatally poisoned by 2.315 milligrams per kilogram. Although one animal survived a slightly larger dose, the results in general appear to indicate that this figure is very close to the minimum lethal dose and for the purpose of this paper is so considered.

Although fewer of the experiments with cattle than with sheep furnish data regarding the degree of illness caused by different quantities of hydrocyanic acid, they furnish some evidence regarding the minimum toxic and the minimum lethal doses.

The smallest quantity which produced definite symptoms was 0.882 milligram per kilogram of animal weight. Following a dose of one half of this quantity or 0.441 milligram the pulse was somewhat accelerated. No other evidence of effect was noted and it was thought the pulse effect might be due in part at least to other causes. As the dose of 0.882 milligram caused very definite symptoms, consisting of accelerated pulse and respiration, nervousness, trembling and slight weakness, it would appear that for cattle the minimum toxic dose is somewhat less than 0.882 milligram, but more than one half this quantity.

A dose of 2.315 milligrams, or the minimum lethal dose for sheep, killed a cow and was thought by the observers to be somewhat more than would have been necessary to produce fatal results with the animal used in the experiment. In fact, one cow, not shown in Table 2, was made very ill on 2.042 milligrams and it was thought she would

TABLE 2.—Doses, Calculated as Hydrocyanic Acid, Given to Cattle and the Severity of Illness Produced when no Remedy was Used

Date	Animal No.	Dose given mg/kg and severity of effect				
		Not sick	Symptoms	Sick	Very sick	Death
1933 Dec. 4	1267					2.315
Nov. 17	1265		1.021			
Nov. 28	1267		.992			
Nov. 28	1266		.882			
Nov. 28	1265	0.441				

have died had remedial measures not been taken. Apparently the minimum letal dose then is close to the latter quantity. Both the minimum toxic and the minimum lethal doses appear to be slightly less for cattle than for sheep.

REMEDIES USED AND THE RESULTS OBTAINED

As previously stated several substances have been used by various investigators to counteract the effects of hydrocyanic acid on animals.

TABLE 3.—EFFECTS AND OTHER DATA REGARDING SUBSTANCES USED EXPERIMENTALLY IN TREATING SHEEP AND CATTLE THAT WERE POISONED BY HYDROCYANIC ACID.

Animal and designation	Date of experiment	Dose of HCN		Treatment			Minutes between giving HCN and giving remedy	Result
		Mg. per kg.	Times m.l.d.	Substance and strength of solution	Quantity given cc.	How given		
Sheep 1309	10– 3–33	3.307	1.42	Methylene blue 1 per cent	30	Intra-peritoneal	3	Death
Sheep 1313	10– 9–33	3.307	1.42	do	50	do	4.5	Recovery
Sheep 1300	10– 9–33	3.307	1.42	Sodium tetrathionate 10 per cent	10	Drench	At same time	do
Sheep 1305	10– 6–33	3.858	1.66	do	30 in 3 doses	Intra-peritoneal	5 to 1st dose 7 to 2nd dose 9½ to 3d dose	Death
Sheep 1314	10– 6–33	3.307	1.42	do	20 in 2 doses	do	3.5 to 1st dose 4 to 2nd dose	do
Cattle 1264	11– 2–33	2.85	1.39	Sodium thiosulphate 10 per cent	20	Intravenous	6	Recovery
Sheep 1315	10– 3–33	3.307	1.42	do	10	Intra-peritoneal	2	do
Sheep 1310	10– 9–33	3.307	1.42	do	20	do	3	do
Sheep 1300	10– 9–33	3.858	1.62	do	20	do	3	do

Cattle 1263	9–28–33	2.042	1±	Sodium nitrite 10 per cent	20	Intravenous	10	Recovery
Do	9–29–33	3.063	1.5	do	20	do	21	Death
Sheep 1310	10– 3–33	3.307	1.42	do	20	Drench	0	Recovery
Sheep 1304	10– 2–33	3.307	1.42	do	10 in 2 doses	Intra-peritoneal	3 to 1st 6 to 2nd	do
Sheep 1305	10– 2–33	3.307	1.42	do	10	do	11	do
Sheep 1306	10– 6–33	3.858	1.66	do	10	do	10	Death
Sheep 1311	10– 3–33	4.410	1.9	do	20 in 2 doses	do	2 to 1st 25 to 2nd	do
Sheep 1304	10– 6–33	4.410	1.9	do	20 in 2 doses	do	8 to 1st 9 to 2nd	do
Cattle 1264	11–10–33	4	1.96	Sodium thiosulphate 20 per cent and sodium nitrite 20 per cent	10 10	Intravenous	4	Recovery
Cattle 1265	11–17–33	4.084	2	Sodium thiosulphate 20 per cent and sodium nitrite 20 per cent	10 10	do	4.5	do

TABLE 3 (Concluded)

Animal and designation	Date of experiment	Dose of HCN		Treatment			Minutes between giving HCN and giving remedy	Result
		Mg. per kg.	Times m.l.d.	Substance and strength of solution	Quantity given cc.	How given		
Cattle 1266	1– 8–34	5.105	2.54	Sodium thiosulphate 20 per cent and sodium nitrite 20 per cent	30 10	Intravenous	6.5	Death
Cattle 1265	12– 4–33	6.126	3	Sodium thiosulphate 20 per cent and sodium nitrite 20 per cent	10 10	do	3.5	do
Cattle 1264	11–17–33	8.168	4	Sodium thiosulphate 20 per cent and sodium nitrite 20 per cent	10 10	do	4	do

Two or more experiments were tried either singly or in combination, with each of the following: methylene blue, sodium thiosulphate, sodium tetrathionate, and sodium nitrite. Methylene blue was used with two sheep only. In each case it was given intraperitoneally. All remedies were given to cattle intravenously. The cyanide was administered as potassium cyanide.

It was desired to obtain information as to whether the remedies themselves acted by chemical transformation with the cyanide. Two sheep were given mixtures by mouth. One received a dose containing 1.42 m.l.d. of the cyanide mixed with 10 cc. of 10 per cent sodium tetrathionate solution and the second received a dose of 1.42 m.l.d. of cyanide mixed with 20 cc. of 10 per cent sodium nitrite solution. In both cases the animals became sick and exhibited typical early symptoms of cyanide poisoning. Both, however, soon showed improvement and recovered in a short time. The experiments indicated that the antidotal action of the remedies had taken place in the organism and that, therefore, the antidotal action is physiological. Had the remedy reacted completely with the cyanide *in vitro* the sheep would not have exhibited any symptoms of poisoning.

The substances used as remedies, together with the results and other data, are given in Table 3. In the opinion of the observers, several of the animals that died would probably have recovered if additional remedial measures had been used to support the experimental treatment.

Methylene blue

Two sheep, each given 3.307 milligrams of hydrocyanic acid per kilogram of body weight or 1.42 times the minimum lethal dose, were treated with intraperitoneal injection of a 1 per cent solution of methylene blue. One given 30 cc. 3 minutes after the prussic acid was given, and in the spasm stage of the illness, died. In this case it was not apparent that the illness was altered by the methylene blue. The second sheep was given 50 cc. of methylene blue solution intraperitoneally 4.5 minutes after the cyanide was administered and recovered. In these cases 50 cc. of 1 per cent methylene blue given intraperitoneally protected against 1.42 times the lethal dose. Three and one-half minutes after the methylene blue was given, the animal showed marked improvement and thirteen minutes later it got up.

Sodium tetrathionate

Of three sheep treated with sodium tetrathionate, one recovered and two died. The one which recovered was given a quantity of cya-

nide equivalent to 1.42 times the minimum lethal dose to which had been added 10 cc. of a 10 per cent solution of sodium tetrathionate. The two substances were mixed and given together as a drench. The sheep went through the early symptoms of hydrocyanic acid poisoning, but these did not reach the spasm stage. The illness was mild and within 13 minutes the sheep had completely recovered.

In one case 20 cc. of a 10 per cent solution of sodium tetrathionate given intraperitoneally failed to protect against 1.42 lethal doses of the cyanide and in another case 30 cc. failed to protect against 1.66 lethal doses. In one of these cases 3.5 minutes and in the other 5 minutes elapsed after the cyanide was given before the first injection of the remedy was administered. In these cases the sodium tetrathionate did not appear to be very effective as a remedy. Both animals had reached the spasm stage of illness and were prostrated when the tetrathionate was administered.

Sodium thiosulphate

This was tried experimentally with one cow and three sheep. Twenty cc. of a 10 per cent solution given intravenously to a cow 6 minutes after the cyanide was administered and 1.5 minutes after convulsions started protected the animal against 1.39 lethal doses. Improvement was noted in the animal's respiration within 1.5 minutes after the thiosulphate was given. One hour later the cow was looking bright and resting comfortably. She did not get to her feet for some hours later.

With one sheep 10 cc. and with another 20 cc. of a 10 per cent solution given intraperitoneally protected against 1.42 lethal doses when administered 2 and 3 minutes respectively after the cyanide was given. In a third case 20 cc. of the thiosulphate protected against 1.62 lethal doses. This was given 3 minutes after the acid was given. These three sheep were down on their sides and one of them, sheep 1310, was having spasms at the time.

Sodium thiosulphate under the condition of the experiment protected against 1.39 lethal doses of hydrocyanic acid in cattle and 1.62 lethal doses with sheep. It was, however, given during the early stages of the illness or before the evidences of respiratory paralysis became pronounced.

Sodium nitrite

Another substance used experimentally as an antidote for hydrocyanic acid poisoning was sodium nitrite. This, in a 10 per cent solu-

tion, was used intravenously on two poisoned cattle cases and as a drench or intraperitoneally with six sheep.

A cow given one lethal dose of cyanide recovered when given 20 cc. of a 10 per cent solution of the nitrite. In this case the nitrite was not given until ten minutes after the cyanide was administered or until the cow was down on her side and kicking spasmodically. The following day this animal was given 1.5 lethal doses of cyanide and 21 minutes later treated with 20 cc. of 10 per cent sodium nitrite solution given intravenously. At the time the nitrite was given she was prostrate on one side, the pulse was fast and beginning to grow weaker than it had been. No beneficial effect from the nitrite was noted. She died very shortly after the nitrite was administered.

One sheep given as a drench 1.42 lethal doses of cyanide to which was added 20 cc. of 10 per cent sodium nitrite developed the early symptoms of cyanide poisoning. The sheep became weak and went down on its side. She began to improve almost immediately and in 10 minutes after falling and 12 minutes after being drenched she had apparently almost completely recovered.

Two sheep given 1.42 lethal doses of cyanide and later given intraperitoneal injection of 10 per cent sodium nitrite recovered. In one case the nitrite was administered in two doses of 5 cc., one in 3 minutes or just after the sheep fell, and the second in 6 minutes after the cyanide was administered. The second sheep was treated with a single dose of 10 cc. of the nitrite solution. This was given 11 minutes after the sheep was drenched with cyanide, or 8 minutes after it went down on its side. At this time the paralytic effects of the cyanide on the respiration were beginning to be apparent.

When given ten minutes after 1.66 lethal doses of cyanide were administered 10 cc. of a 10 per cent solution of sodium nitrite failed to save the animal. Similarly 20 cc. of the nitrite failed to save two sheep that had been given 1.9 lethal doses each of cyanide even when the first half of the nitrite was administered shortly after the animal became ill. In one case 10 cc. was administered in 2 minutes and a second 10 cc. was given to the sheep in 25 minutes. In a second case the first 10 cc. was given in 8 minutes and the second 10 cc. in 9 minutes. Both sheep died.

Sodium thiosulphate and sodium nitrite combined

As sodium thiosulphate and sodium nitrite have different actions, both substances were administered to five poisoned cattle. In these cases 20 per cent solutions were used, one being administered im-

mediately after the other. They were given intravenously. In two cattle, when these were administered within 4 and 4.5 minutes after the cyanide was given, the two substances protected against 1.96 and 2 lethal doses of the cyanide. In two other cases, similar doses of the thiosulphate and nitrite failed to protect against 3 and 4 lethal doses of the cyanide when 3.5 and 4 minutes respectively were allowed to elapse between the giving of the cyanide and the administering of the experimental remedy.

Similarly 10 cc. of sodium nitrite and 30 cc. of sodium thiosulphate did not prevent the death of a cow that had received 2.54 lethal doses of cyanide 6.5 minutes previously to the administering of the experimental remedy. In other words, by giving intravenous injections of sodium thiosulphate and sodium nitrite it was found possible to save cows poisoned by as much as 2 lethal doses of cyanide, but not when 2.54 lethal doses or more had been given.

SUMMARY

Experiments with sheep and cattle were made to determine the relative efficiency, under practical conditions, of four substances that have been suggested as remedies for cyanide poisoning. The substances used were methylene blue, sodium tetrathionate, sodium thiosulphate, sodium nitrite, and a combination of the two latter.

The animals were given drenches of potassium cyanide in water and the remedies were given at various times after the cyanide was administered. Except for two sheep for which the remedy was mixed with the cyanide and administered as a drench, the remedies were injected intraperitoneally and in the cattle they were injected into the jugular vein. All of the substances tried, offered some protection against the poisonous action of the cyanide.

The minimum lethal dose of hydrocyanic acid, administered as potassium cyanide in a drench, was determined to be; for sheep 2.315 mg. per kilo; for cattle nearly 2.042 mg. per kilo. The minimum toxic dose was found to be; for sheep 0.992 mg. per kilo; and for cattle somewhat less than 0.882 mg. per kilo.

In the experimental work with sheep 50 cc. of methylene blue protected against 1.42 lethal doses of cyanide, although 30 cc. failed to do so. Of the other remedies tried, sodium tetrathionate and sodium nitrite, each protected against 1.42 minimum lethal doses but failed to do so against slightly larger doses. Sodium thiosulphate protected against 1.62 minimum lethal doses. The combination of sodium thiosulphate and sodium nitrite was not tried with sheep.

In the cattle experiments, sodium nitrite protected against a single minimum lethal dose of cyanide but failed to do so when 1.5 minimum lethal doses had been given. Sodium thiosulphate protected against 1.39 minimum lethal doses. With cattle the best results were obtained with a combination of sodium nitrite and sodium thiosulphate which protected against 2 minimum lethal doses. Methylene blue and sodium tetrathionate were not used with poisoned cattle.

The results strongly indicate that in administering any of the substances tried as remedies it is of the utmost importance that they be given very promptly after symptoms of poisoning develop and before the period of respiratory paralysis sets in.

Aside from these remedies no other treatment was given the sick animals. It is our opinion based on our observations of the course of the sickness that in several cases additional treatment such as the stimulation of respiration and general supportive measures would possibly have altered the final result of the cases. It is suggested that, in cases of cyanide poisoning, treatment with the remedies used in this study could well be supplemented by other measures with better chances of success.

Two experiments indicate that the remedial action of nitrite and tetrathionate is physiological rather than chemical.

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CHEMISTRY.—*The pigment of the India red pummelo* (Citrus grandis *Osbeck*).[1] M. B. Matlack, Bureau of Chemistry and Soils. (Communicated by J. A. LeClerc.)

Through the courtesy of Dr. Walter T. Swingle of the Bureau of Plant Industry, the writer obtained three fruits of the India red pummelo from tree CPB 10058 of the Eustis Experiment Garden, Eustis, Florida. Since the pink grapefruit is a close relative of this fruit it was thought of interest to determine the nature of the pigment. Previ-

[1] Received May 21, 1934.

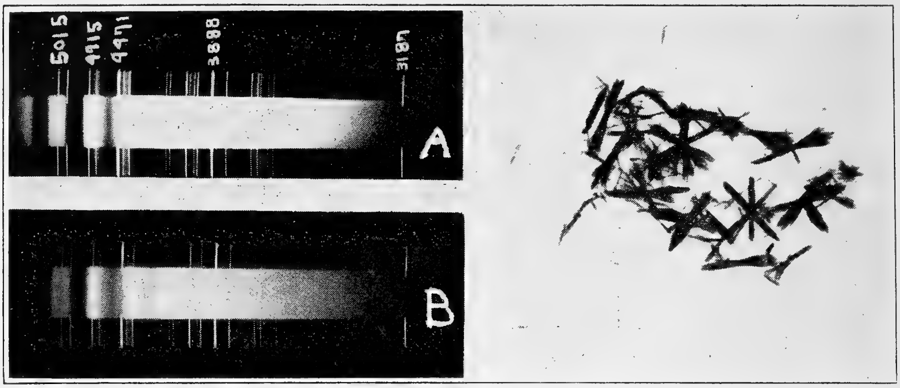


Fig. 1.—*Left*, A. Tomato lycopene; B. India red pummelo lycopene. *Right*, India red pummelo lycopene crystals ×180.

ously the writer had shown by microchemical crystallization methods that the pigment of the India red pummelo and that of the pink grapefruit were the same, namely, lycopene.[2] Microchemical evidence is not so positive as actual isolation, however, and since the opportunity was at hand the pigment of the three fruits was isolated. The total amount isolated was probably not much more than a milligram, but the material was not dryed and weighed for fear of losing it.

Although there was some pigment in the peel this was discarded, since it was desired to avoid contamination with the volatile oil. Only the pulp and locular membranes were used. The separated material, after being crushed in a mortar in order to break up the pulp cells, was treated with 95 per cent alcohol and pressed to remove the excess. It was then treated again with 95 per cent alcohol and dried at room temperature. The dried material was extracted with carbon disulfide, the carbon disulfide evaporated almost to dryness and absolute ethyl alcohol added, producing a precipitate of red crystals. These were purified by dissolving in a small amount of carbon disulfide and precipitating with petroleum ether. Identification was made by comparison of the absorption spectrum[3] of the pigment with that of an authentic sample of lycopene from the tomato.

Fig. 1-A shows the spectrogram of tomato lycopene and Fig. 1-B that of the pigment of the India red pummelo taken at liquid air temperature. Fig. 1 (right) shows a photomicrograph of lycopene crystals from the India red pummelo.

[2] *Some preliminary observations on the coloring matter of Citrus fruits.* Amer. Journ. Pharm. **100**: 243–246. 1928.

[3] The writer is indebted to Dr. G. E. Hilbert and E. F. Jansen of the Bureau of Chemistry and Soils, U. S. Dept. of Agriculture, for the spectrograms.

PALEONTOLOGY.—*Pleistocene remains found near Lake Tacarigua, Venezuela.*[1] CHARLES T. BERRY. (Communicated by EDW. W. BERRY.)

In the past few years some very interesting archaeological work has been done around the eastern end of Lake Tacarigua, commonly noted on some recent maps as Lake Valencia or Lake Maracay, a part of which is in the State of Aragua, Venezuela. Lake Tacarigua is situated about 25 miles inland from the northern coast of Venezuela at an altitude of about 1400 feet. Dr. Rafael Requena, who conducted the archaeological work, has brought to light many finds which suggest a lake-dwelling type of people. With these human remains were found many shells both marine and terrestrial, all well preserved. These shells and several small samples of the material in which they were found, were collected from Bennet Mound near La Mata and were forwarded to me from Dr. Requena through Dr. J. A. Tong of Caracas, Venezuela. It is this material which forms the basis of the present paper.

I wish to express my sincere thanks to Dr. Henry A. Pilsbury of the Academy of Natural Sciences of Philadelphia for identifying the shells sent him. To K. E. Lohman of the United States Geological Survey I am indebted for the determination of the diatoms and sponge spicules found in the marl bed. Also I wish to thank Dr. C. H. Blake of the Massachusetts Institute of Technology for the identification of the ostracods found in the marl bed.

It is common knowledge that most prehistoric people had trade routes by means of which they traded implements and ornaments. The marine organisms found near Lake Tacarigua had been used for two purposes; food, and the shells for ornamentation. This fact means that the people of that time must have made the trip in a comparatively short time from the sea coast to their homes or else the food would have spoiled in the tropical climate.

The complete list of marine shells that I received, which were found in the upper bed are:

Codakia orbicularis
Fissurella rosea Fischer.
Fissurella nodosa Born.
Cittarium pica Linné.
Nerita versicolor Gmel.
Tectarius muricatus Linné.
Strombus gigas Linné.
Oliva recticularis Lam.

[1] Received Nov. 11, 1933.

The shells of *Strombus gigas* are broken in such a manner as would occur only if the animal had been used for food. Of the two different species of limpets (*Fissurella* spp.) those belonging to *Fissurella rosea* show undoubtedly that they were used as ornaments. The edges of the shells are smooth and show evidence of having been shaped. The slit in the apex of the shell was very useful for stringing on some variety of cord, thus making a necklace. Requena[2] pictures several such necklaces of limpets and other shells. *Oliva recticularis* has a straight hole running through the shell lengthwise from the apex to the lower end of the aperture. Again in both *Nerita versicolor* and *Tectarius muricatus* the shells have a small oblong hole in the first whorl, just opposite the aperture. In *T. muricatus* the holes are worn smooth along the edges and in *N. versicolor* the teeth on the outer lip of the aperture are nearly all worn away.

The fossils which I have received have come from two successive beds. The upper one—which is covered by about 8 feet of top soil consisting of sand and clay—is from 2 to 3 feet thick. The lower bed—which has been penetrated to a depth of 2 feet by the archaeological excavations—is of unknown thickness. This lower bed is a freshwater marl, consisting entirely of calcareous material. The areal extent of this bed, however, is as yet not known. Innumerable shells of *Planorbis pronus* are the dominant organisms found in the lower bed. Apparently at the time this bed was deposited the waters teemed with ostracods, for it now contains literally millions of them. However, there seem to be only a limited number of species represented. They belong to the following genera; *Cryptocandona, Dolerocypris, Spinocypris, Cyridopsis, Potamocypris, Darwinula,* and *Cytheridella.* Numerous fish scales, ribs, and vertebral ossicles were found which have been determined as belonging to *Geophagus brasiliensis.* This fish seems to have been the most common, if not the only one, which inhabited the lake at that time. It is a species that inhabits freshwater in tropical regions of both South America and Africa today. It is similar in size, color, and habits to our common sunfish of North America. Many scales, ribs, and vertebral ossicles were found in the upper bed also. Some small *Unio* shells were also found, but were too young to be definitely determined.

The following is the complete list of all the different organisms found in the lower or marl bed;

Fishes

Geophagus brasiliensis Quoy & Gaimard

[2] REQUENA, R. *Vestigios de la Atlantida.* Caracas. p. 47. 1932.

Mollusca
- *Planorbis pronus* v. Mart.
- *Potamopyrgus parvulus* Gldg.
- *Unio* sp.
- Snail teeth

Eucrustacea
- *Cryptocandona valencia* n.sp. Blake
- *Dolerocypris berryi* n.sp. Blake
- *Spinocypris macracanthos* n.g. et n.sp. Blake
- *Cypridopsis fuhrmanni?* Mehes
- *Potamocypris* sp.
- *Darwinula* sp.
- *Cytheridella tacarigua* n.sp. Blake

Diatoms
- *Melosira* cf. *M. italica* (Ehrenberg) Kützing
- *Melosira* cf. *M. sulcata* (Ehrenberg) Kützing
- *Cyclotella meneghiniana* var. *rectangulata* Grunow
- *Stephanopyxis corona* (Ehrenberg) Grunow
- *Fragilaria brevistriata* Grunow
- *Fragilaria construens* (Ehrenberg) Grunow
- *Sceptroneis* sp.
- *Synedra* cf. *S. ulna* (Nitzsch) Ehrenberg
- *Navicula* cf. *N. halophila* (Grunow) Cleve
- *Navicula* cf. *N. occoneiformis* Gregory
- *Pinnularia* cf. *P. dactylus* Ehrenberg
- *Anomoeoneis sphaerophora* (Ehrenberg) Pfitzer
- *Gomphonema ventricosum* Gregory
- *Cymbella ventricose* Kützing
- *Epithemia* sp.
- *Rhopolodia gibba* (Kützing) Müller
- *Rhopolodia ventricosa* (Kützing) Müller
- *Nitzschia* cf. *N. dubia* Wm. Smith
- *Nitzschia* sp.

Seeds
- *Chara requena* n.sp.
- *Chenopodium* sp.
- *Eupatorium* sp.

Sponge spicules
- *Ephydatia aufioxa* J. Frenguelli
- *Ephydatia aufidiscos* J. Frenguelli

All the diatoms are found living in fresh or brackish water with the exception of three species. These three species, which appear to be very rare and much broken, are; *Melosira sulcata*, *Stephanopyxis corona*, and *Sceptroneis* sp. (probably *S. caduceus*). The first of these lives in marine and brackish water today and has been found in the Middle Miocene of North America along with *Stephanopyxis corona* and *Sceptroneis caduceus*. The last two species, however, are both extinct. The presence of these Miocene diatoms in the fresh-water marl bed probably means that they were reworked from some Miocene

deposit in the region of Lake Tacarigua. Although no Miocene deposits are known very close to Lake Tacarigua the minuteness of these diatoms makes it easily possible for them to be carried great distances before they are redeposited. The sponge spicules have been found in tripoli deposits of Quaternary age from Chile.

I was able to determine a few of the seeds found in this marl bed; one, a new species of *Chara* and one each of *Chenopodium* and *Eupatorium*. However the majority had to be left undetermined for want of comparative material.

Chara requena n.sp.

Figs. 6, 7.

The oogonium is very minute, being 79.8μ long and 52.5μ broad. It is elliptical in profile and circular in cross section. There are 12 convolutions which form a low spiral. The spiral cells are concave making a deep furrow between the extended keels of the cell margins. The width of the cell taken from keel to keel is 5.8μ in the center region of the oogonium. There is a round hole at the basal end while the cells unite in a low nondescript rosette at the apical end.

Six specimens of *Chara* oogonia were found in the lower fresh-water marl bed and only one in the overlying bed. They appear to be all of the same species; however, the lone specimen from the upper bed is somewhat larger than the rest. Most of the specimens have their apical or basal end broken so I have therefore taken the most perfect one as the type and described it above. I have given this *Chara* oogonium the specific name of *requena* in honor of Senõr Rafael Requena.

James Groves[3] states that *Chara perpusilla* is the smallest charophyte that has been found in the Tertiary deposits. The dimensions for the oogonium of this species he gives as 275–300μ long and 200–250μ broad. These dimensions greatly exceed those of the above described species.

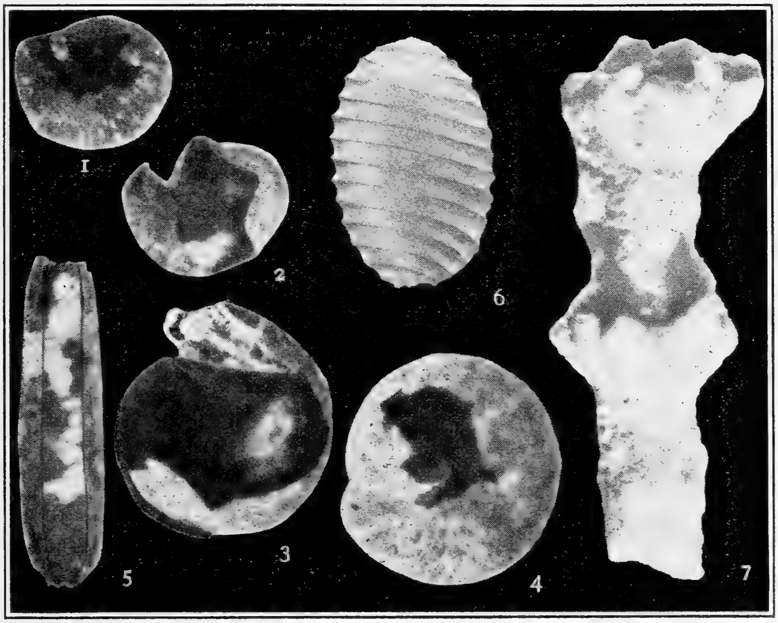
With these *Chara* oogonia were found numerous pieces of stems, all similar in appearance. One piece (Fig. 7) was preserved showing two nodes. On the upper node there are the remains of six branches while on the lower node there appear to be seven branches. It is safe, I think, to say that these pieces of stem belong to the same species as the oogonia do, as only one type of oogonium is present in these deposits.

CHENOPODIUM sp.

Figs. 1–4.

In the lower fresh-water marl bed I found four seeds which belong to the genus *Chenopodium*. All these seeds are very small and poorly preserved. In most of them the outer black coating—which is made up of a hard thick material, irregularly pitted—has been partly broken off thus showing the

[3] GROVES, J. *The Bembridge Flora. Cat. Cainozoic Plants* by E. M. REID and M. E. J. CHANDLER. Brit. Mus. Nat. Hist. **1**: 173. 1926.



Figs. 1–4.—Seeds of *Chenopodium* sp. ×19. 5 Seed of *Eupatorium* sp. ×19. 6 Seed of *Chara requena* n.sp. ×42. 7 Stem of *Chara requena* n.sp. ×29.

gray fibrous underlying layer. One end of the coiled embryo can be seen clearly, for it has broken away from the general elliptical profile of the seed. The groove which runs down from the crest to the periphery of the seed can be partly discerned. This groove marks the position of the embryo on the inside.

Chenopodium is a very wide spread herb, which in certain regions reaches the size of a small shrub. It is found growing in South America today and this fossil species is probably represented by some present day species of *Chenopodium* living in the same region. With such poorly preserved seeds it is not possible to identify them with living species.

Eupatorium sp.

Fig. 5.

One poorly preserved seed of *Eupatorium* was found in the lower fresh-water marl bed. This seed is partly covered by a white calcareous material so that only a portion of the outside surface is exposed. The entire outside surface of the seed—which is divided into five long flat rectangular areas by longitudinal ridges—is covered by a minute semi-rectangular network of ridges. The seed is about four times as long as it is broad and both of its ends are broken open.

Eupatorium is a very wide spread genus of plants, found in both North and South America. I am certain that the same species now lives in the region of Lake Taçarigua, but I have been unable to procure any compara-

tive material which would permit one to give a specific name to this lone seed.

Apparently this lower marl bed was being deposited, or had just been deposited, when the lake dwellers came to the region; for in this bed have been found piles upon which the people constructed their houses. However, no artifacts of any kind were found. What climatic or earth changes took place to alter what was apparently a clear, freshwater lake into one full of mud, I do not know. But evidently this alteration took place about the time the lake dwellers came.

The upper bed, which is 2 to 3 feet thick, is the type of deposit that would be laid down in muddy water containing much vegetable matter. Some of the animals which appeared in the underlying marl still survived, but most of the fauna of the upper bed is different. The same Ostracods are present, but their number has decreased almost to the vanishing point. Also *Planorbis pronus,* which was so abundant in the lower bed is very scarce in this upper bed. Large gastropods predominate and it is a question whether they are indigenous or had been used as food and the shell remains thrown overboard. The same fish (*Geophagus brasiliensis*) inhabited the water. Small pieces of wood, which are carbonized, have their structure well enough preserved so that one is able to say that they belong to some dicotyledon similar to many Lauraceae. This, or similar tropical hard wood, probably formed the piles upon which the lake dwellers built their houses. It is within this bed that human remains have been found, proving that this deposition was contemporaneous with, or just antecedent to, the time of the lake dwellers.

The following is a list of the different forms (omitting the marine fauna) found in the upper bed:

Fishes
- *Geophagus brasiliensis* Quoy & Gaimard

Mollusca
- *Planorbis lugubris* Wagner.
- *Planorbis pronus* v. Mart.
- *Labyrinthus plicatus* Born.
- *Auris dictorta* Brug.
- *Pomacea glauca* Linné.
- *Pomacea glauca dubia* Guilding.
- *Pomacea cinqulata* Philippi.
- *Pomacea aurostoma* Lea.
- *Strophocheilus oblongus* Müller.
- *Plekochielus venezuelensis* Nyst.
- *Unio* sp.
- *Cerion uva* Linné.

Eucrustacea
Cryptocandona valencia n.sp. Blake.
Dolerocypris berryi n.sp. Blake.
Spinocypris macracanthos n.g. et n.sp. Blake.
Cypridopsis fuhrmanni? Mehes.
Potamocypris sp.
Darwinula sp.
Cytheridella tacarigua n.sp. Blake.
Seeds
Chara requena n.sp.

The most difficult question in connection with these deposits is their age. The marine forms which were used both as food and ornaments, inhabit the present day Venezuelan shore. The terrestrial forms also are found in the region, with the exception of *Cerion uva.* Traces of color patterns can be observed in individuals of both classes of shells, but there is also undoubted evidence that most of the shells have been buried for a great number of years.

Requena[4] lists the following fossils as having been found with the human remains:

Marine
Triton variegatus
Strombus pugilis
Cypraea exantema
Lucina tigerina
Lucina jamaicensis
Oliva jaspidea
Fissurella sp.
Nerita sp.
Terrestrial
Pachychilus laevissimus
Planorbis olivaceus
Ampullaria glauca
Ampullaria urceus
Bulimus pardalis
Bulimus distortus
Strophia uva

The above list shows some evident differences from mine. These differences can be due either to the fact that there may have been some mistake in the identification in the older list that Requena has published or to the fact that I did not receive a complete representation of the fauna which is to be found there. I am of the opinion that probably both explanations are true.

The only outstanding shell which could give any clue to the age of the deposits is a small worn shell of the land mollusc, *Cerion uva.* This land snail is an inhabitant of the Island of Curaçao and has never

[4] Requena, R.—*Op. cit.* p. 242.

been reported from the mainland before. Curaçao is a small island off the coast of Venezuela, 130 miles in a direct line northwest of Lake Tacarigua. Did it live in the region of Lake Tacarigua in these prehistoric times and since become extinct, except on this one island, or was it imported by humans for some object of ornamentation such as for necklaces or the like, or did it come on drifting objects brought by the sea currents?

Of the three alternatives which present themselves as an explanation of why *Cerion uva* is present in these deposits, one can be ruled out with considerable assurance. That is, that ocean currents acted as agents for transportation. This is impossible for the Southern Equatorial Current which travels westward across the Atlantic divides into two parts at Cape San Roque. One part which travels northward is the Guiana Current, the other which flows southward, the Brazil Current.[5] The current which skirts the northern shore of South America is called the Main Equatorial Current, but as it nears the West Indies it is known (by some authors) as the Guiana Current. This current enters the Caribbean Sea between the Lesser Antilles and the mainland of South America and skirts the northern shores of Venezuela. Thus there could be no drifting of material in an eastward direction as would be necessary if *Cerion uva* originated on the Island of Curaçao. This leaves the two other questions to be discussed—man as the sole agent of transportation; or—the specimen is indigenous. Both explanations are quite plausible. For, as we have already seen, these prehistoric people traveled and brought in marine organisms for food. They may very well have traveled the entire distance from the Island of Curaçao to Lake Tacarigua. The last question is—is *Cerion uva* indigenous? That is possible, but I have very little definite evidence—one badly worn specimen—to base such an assumption on. However, included in Senōr Requena's list[6] of the fossils found in the region is *Strophia uva* which is just another name for *Cerion uva.* This shows that there was more than one specimen of the shell present in these deposits. This fact lends a somewhat greater probability to the hypothesis that *Cerion uva* is indigenous to the region of Lake Tacarigua. However, the evidence is inadequate to decide between the two possibilities.

The fossils now at hand throw little light on the age of these beds. Most of the fossils found live in the same region today with the ex-

[5] Guppy, H. B. *Plants, seeds and currents in the West Indies and Azores*, p. 60. 1917.

[6] Requena, R. *Op. cit.*, p. 242.

ception already noted. However, I think one can be fairly safe in saying that these deposits were laid down during the late Pleistocene epoch. It is always necessary to bear in mind while discussing the Pleistocene of the tropics that no pronounced change between it and the Recent took place. Probably the age of these deposits could be more surely determined if one had a complete collection of all the fossils which are to be found in the two beds.

BOTANY.—Pedilospora dactylopaga *n.sp., a fungus capturing and consuming testaceous rhizopods.*[1] CHARLES DRECHSLER, Bureau of Plant Industry.

In permitting the development of a microscopic fauna, however restricted in variety of types, agar plate cultures made for the purpose of isolating fungi from diseased rootlets and other decaying plant materials, often afford a tolerably abundant growth of adventitious fungi destructive to different species of the more minute terrestrial invertebrates. As the destruction takes place in a transparent substratum the parasitic and predacious relationships are conveniently exposed to view. Fungi that on a natural substratum show only their aerial conidial apparatus, and would therefore ordinarily be taken, indeed, in some cases have long been taken, for saprophytes, are revealed in their true carnivorous character. Very probably because nematodes and amoebae of various species multiply most freely in agar plate cultures, instances of predacious and of parasitic activity involving these animals as prey or as hosts can be more frequently seen than instances of destruction of other microscopic animals. The capture of two species of testaceous rhizopods identified as *Difflugia globulosa* Duj. and *Trinema enchelys* Ehrenb. that I had opportunity to observe recently, provides therefore an element of novelty which is accentuated by the curious morphology of the fungus concerned.

As on agar plate cultures at least, the two rhizopods mentioned, like most other shelled protozoans, are decidedly sluggish in movement, their capture entails no violent struggle. That *Trinema enchelys* does not accept its fate altogether passively is indicated in the overturned posture of many a specimen, the mouth of which is directed upward rather than downward as normally. Except for such abnormal posture, captured animals are to be distinguished for the most part only by what on cursory examination would seem to be ordinary contact with a short branch on one of the superficial fila-

[1] Received June 18, 1934.

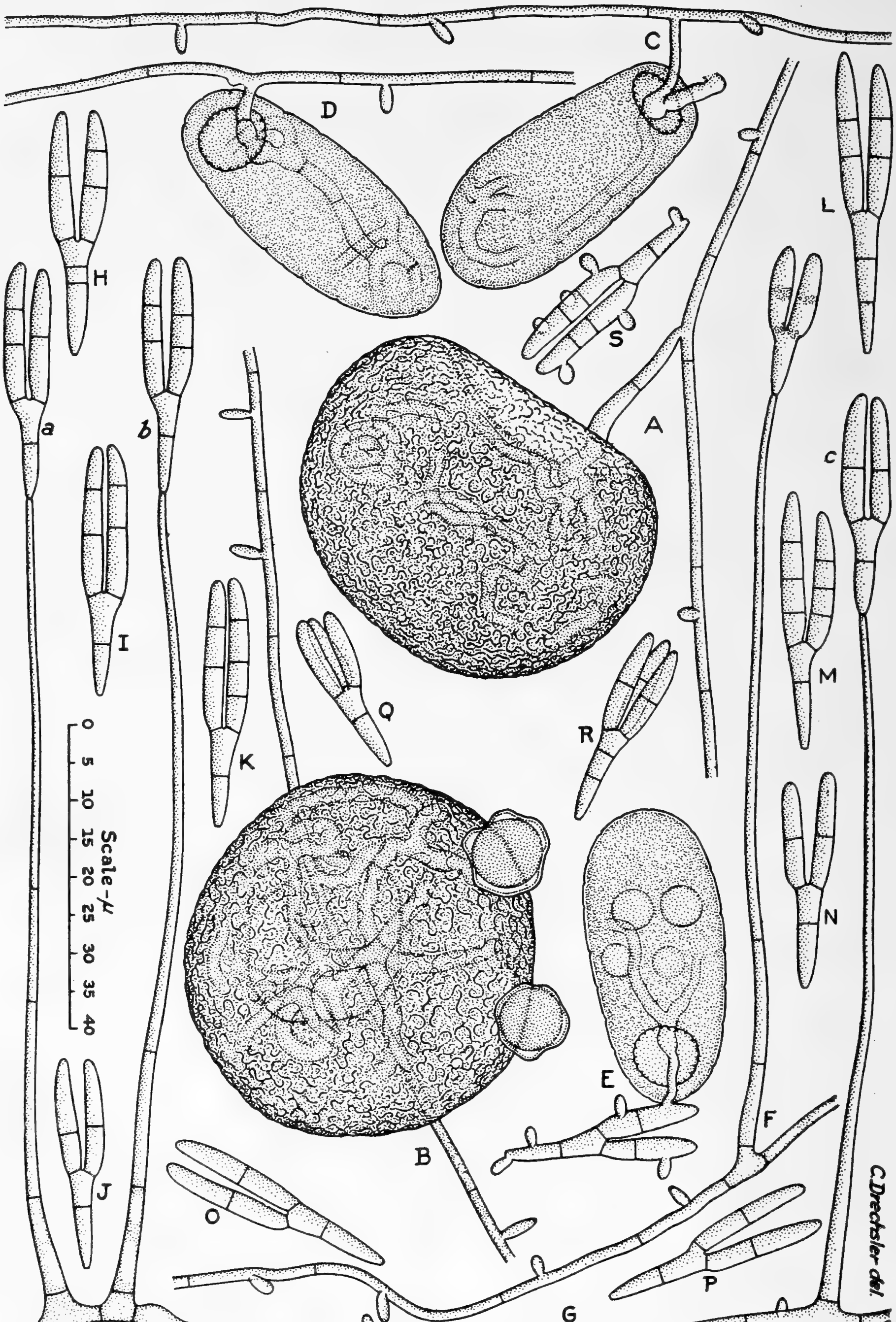


Fig. 1. *Pedilospora dactylopaga.* For explanation see opposite page.

ments that make up the sparse mycelium of the fungus. On closer examination the reason for the persistence of the contact, and the resultant immobility of the rhizopod, becomes sufficiently evident in that the branch is revealed as not merely being in contact with the animal at the unprotected mouth region, but as having penetrated into the protoplasmic interior and developed there a branched endozoic mycelium. This endozoic mycelium, which, as might be expected, attains a greater extension in the bulky *Difflugia* (Fig. 1, A, B) than in the smaller *Trinema* (Fig. 1, C, D, E), gradually exhausts the protoplasm within which it ramifies, until the crumbling or collapse of the enveloping testa announces the completed destruction of the prey.

Though *Difflugia globulosa* and *Trinema enchelys* are sluggish in movement it is yet hardly to be supposed that they could in their normal progression be successfully invaded even by a rapidly growing fungus, much less by a form as slow in linear extension as the one here concerned. The animals evidently must be held in their tracks by some special means until internal mycelial development is well started. This means is clearly provided in the digitate or elliptical diverticulations that are attached to the superficial mycelial filaments at moderate intervals (Fig. 1, A–D, F, G), or, following development somewhat analogous to germination, project in closer arrangement and in numbers, usually up to a half-dozen from detached conidia (Fig. 1, E, S). Frequently the membrane at the tip of the diverticulation appears as if thickened somewhat, but this appearance is better interpretable as due to a deposit of adhesive material than as resulting from local reinforcement of the wall. The branch connecting a well invaded animal with a mycelial filament is usually considerably longer than an undisturbed diverticulum (Fig. 1, A, C–E). An engaged diverticulum manifestly grows out a variable distance before penetration is effected.

Fig. 1. *Pedilospora dactylopaga*, drawn from material developed in mixed culture on maizemeal agar, with the aid of a camera lucida, at a uniform magnification; ×1000. A.—*Difflugia globulosa*, shown in lateral aspect, captured on a hypha of the fungus with endozoic mycelium partly visible. B.—Another specimen of *Difflugia globulosa* captured on a hypha, but shown in dorsal aspect; internal mycelium partly visible; the two irregularly globose bodies representing adhering cysts of a smaller protozoan. C, D.—Captured specimens of *Trinema enchelys*, the mycelium developed internally partly showing through the testa of each animal. E.—*Trinema enchelys* captured on a conidium beset with organs of capture. F.—Portion of hypha bearing 4 organs of capture and a conidiophore on which is borne an immature conidium. G.—Portion of hypha with 3 organs of capture and 3 conidiophores, each of the latter bearing a conidium, *a*, *b*, *c*, respectively. H–P.—Conidia of usual bifurcate type showing variations in size and shape. Q, R.—Conidia of less frequent tridental type. S.—Conidium bearing 6 organs of capture resulting from a process analogous to germination.

Here and there from the prostrate hyphae of the sparse mycelium arise singly or in small groups delicate erect conidiophores, about .1 mm. high, on which solitary pluriseptate bifurcating conidia with parallel or slightly divergent lobes are borne terminally. The characteristic shape of the conidia clearly refers the fungus to *Pedilospora*, a genus erected by Höhnel (10) on a species, *P. parasitans*, that he had found presumably parasitic on an ascomycete identified provisionally as *Helotium citrinum* (Hedw.) Fr. A similar biological relationship was attributed to two congeneric forms described later, *P. ramularioides* Bubák being recorded by its author (2) as a parasite on the mycelium of *Bispora pusilla* Sacc., and *P. episphaeria* Höhnel (11) as possibly a parasite of *Nectria cucurbitula* Fr. It would be easy to infer that the three described species differ widely in biological relationship from the predacious form under consideration, yet the possibility is hardly to be ignored that the parasitism noted by Höhnel and by Bubák may have been more apparent than real. Fruiting bodies of such ascomycetes as *H. citrinum* and *N. cucurbitula* often harbor a respectable microscopic fauna especially under moist conditions and in stages following maturity; and a filamentous fungus destructive to representatives of this fauna could hardly fail to present much the appearance of a parasite on the underlying living substratum.

However, from a consideration of morphological features there can be little doubt that the present fungus is indeed different from any of the three previously described congeners. The range in length of conidium is given as 13 to 16μ in *Pedilospora parasitans*, as 12 to 18μ in *P. ramularioides*, and as 11 to 18μ in *P. episphaeria;* whereas in the present form this dimension varies usually between 20 and 40μ, with the average lying close to 30μ. More important perhaps than the mere excess in length is the fact that most of this excess is accounted for in a proportionately much greater length of the basal portion of the conidium. In *P. parasitans* this part is described as obconical; in *P. episphaeria* as biconical and as measuring 3 to 3.5μ both in length and in width; in *P. ramularioides* as usually tetrahedral, the figures accompanying the text showing approximate equality of length and width. Obviously, in the species dealt with by Höhnel and by Bubák the basal part of the conidium consists of a small isodiametric cell just large enough to serve as junction of the two lobes that together make up by far the greater bulk of the spore.[2] In the fungus

[2] Since the present paper was submitted for publication, a contribution by Z. Gizhitska (Novitates pro flora mycologica. Visnik Kiivs. Bot. Sadu [Bull. Jard. Bot.

under discussion, it is usually rather little inferior in length or in bulk to either of the lobes (Fig. 1, G, *a, b, c;* H–M; O; P; S) and sometimes equals (Fig. 1, N, R) or even slightly exceeds (Fig. 1, Q) the latter in these respects. Associated with the greater length is the presence usually of 1 and less frequently of 2 (Fig. 1, H, L, R) cross-walls. The 2 or 3 axial segments resulting from this septation are of about the same size as the 2, 3 or 4 cells into which each of the lobes is divided through the insertion of 1 (Fig. 1, E; G, *c;* J; N; O; P; R), 2 (Fig. 1, I, L, S) or 3 (Fig. 1, M) septa respectively. As in the congeneric species each of the lobes is constantly delimited from the axial part by a septum. The number of cells in a conidium thus varies from 5 to 11, with 8, distributed as in the specimen shown in Figure 1, I—2 in the basal part and 3 in each lobe—representing the condition to be regarded as perhaps most nearly typical.

Although bilobate conidia having the general shape of a tuning-fork easily predominate, specimens with 3 lobes and thus suggestive of a trident, are not of rare occurrence (Fig. 1, Q, R). Similar tridental conidia were described and figured by Bubák for *Pedilospora ramularioides*, and were mentioned as occurring occasionally also in *P. episphaeria.* The monopodial development of the conidiophore ascribed to these two species has never been observed in my fungus, but might possibly occur under conditions encouraging more abundant sporulation than was afforded by the somewhat scanty supply of shelled rhizopods available in my cultures. In pure culture on artificial media like maizemeal agar, sporulation is generally even more meager than in mixed culture, and sometimes is completely absent. In pure culture, moreover, the undisturbed mycelium and conidia are entirely devoid of the digitate protuberances that evidently represent special organs of capture, a fact not only of much biological interest in itself, but expressive, too, of a physiological parallelism with the various nema-capturing species of *Trichothecium, Dactylaria, Arthrobotrys, Dactylella* and *Monacrosporium* whose consistent failure to produce captivating apparatus in pure culture was referred to earlier (6). In spite of the protuberances being dependent for their production on special ecological conditions, a specific term having reference to them may appropriately bring into relief the predacious

Kyiv] **16:** 43–44. 1 pl. 1933) has been received, wherein a new species is described under the binomial *Pedilospora jaczewskii.* In this species, as in the three described earlier, the two conidial lobes arise from a single, short, relatively small, pentagonal basal cell. Accordingly the same considerations setting the American fungus apart from the species described by Höhnel and by Bubák, serve to set it apart also from the Ukrainian species.

character of the fungus, which seemingly deserves recognition as a new species.

Pedilospora dactylopaga sp. nov.

Mycelium sparsum, repens, parce ramosum; hyphis sterilibus 1.2–2.2μ crassis, hyalinis, mediocriter septatis, hinc inde saepius ad intervalla 15–50μ tubera digitiformia vel elongato-ellipsoidea 2.5–5$\times$1.2–2.2μ verisimiliter glutinosa emittentibus, his tuberibus animalcula capientibus, in eadem penetrantibus et ramos intus evolventibus; hyphis fertilibus paucis, hyalinis, parce septatis, plus minusve erectis, 75–125μ altis, basi 2–3μ crassis, sursum attenuatis, apice circa 1μ crassis. Conidia acrogena, solitaria, hyalina, 20–40μ (saepius circa 30μ) longa, 4–10-septata (typice 7-septata), bilobato-furcata vel interdum trilobato-furcata; parte infera continua vel bi- vel triloculari (typice biloculari), saepius nonnihil breviore quam lobis sed interdum eisdem aequali; lobis 2.5–3.5μ crassis, raro continuis, saepius bi- usque quadrilocularibus (typice trilocularibus), parallelis vel nonnihil divergentibus.

Habitat in radicibus putrescentibus, Difflugiam globulosam et Trinemam enchelyn capiens et consumens, in Washington, D.C.

Mycelium sparse, creeping, rather scantily branched; the vegetative hyphae 1.2 to 2.2μ wide, hyaline, septate at moderate distances, bearing at intervals usually of 15 to 50μ digitate or elongate-elliptical, apparently adhesive protuberances, and by means of these protuberances capturing protozoans, penetrating into them and giving rise to branches inside; conidiophores rather few in number, sparingly septate, hyaline, more or less erect, 75 to 125μ in height, 2 to 3μ wide at the base, tapering toward the tip to an apical diameter of about 1μ. Conidia acrogenous, solitary, hyaline, 20 to 40μ (mostly about 30μ) long, 4- to 10-septate (typically 7-septate), bilobate-furcate or occasionally trilobate-furcate; the lower part consisting of 1 to 3 cells (typically of 2 cells), usually somewhat shorter than the lobes but occasionally equal to them in length; the lobes parallel to or slightly divergent from one another, 2.5 to 3.5μ wide, rarely continuous, mostly consisting each of 2 to 4 (typically of 3) cells in linear arrangement.

Isolated from agar plate cultures started from decaying rootlets collected in Washington, D.C., in which cultures it was found capturing and consuming *Difflugia globulosa* and *Trinema enchelys*.

Höhnel held that *Pedilospora parasitans* could perhaps be most advantageously included in the Mucedineae-Staurosporae. This opinion was carried into effect by Saccardo (14) to whom among compilers the problem of disposing of the genus *Pedilospora* seems first to have presented itself. A similar disposition was made, though with expressed misgivings, by Lindau (12), and more recently again by Clements and Shear (3). In all probability only the outward shape of the conidium was considered by these authors, yet suggestions are not absent that some of the genera with which *Pedilospora* was thus brought into juxtaposition are in whole or in part naturally related to it. The original description of *Trinacrium subtile* Riess given by Fresenius (8), for example, makes mention of sparse mycelial growth

overlying a more robust fungus (*Stilbospora* sp.), thereby supplying a parallelism in habit as well as in habitat to supplement the morphological resemblance between the typically triradiate conidia distinctive of *Trinacrium* and the trilobate conidia occurring, even if only occasionally, in *P. ramularioides, P. episphaeria* and *P. dactylopaga.* The delicate, scarcely visible effuse mycelium and the trident-shaped conidia mentioned by Preuss (13) in his diagnosis of *Tridentaria alba* suggest likewise a general parallelism which is not contradicted in the reported occurrence of the fungus on moist decaying stems of *Brassica oleracea* Linn.,—a substratum that could be expected to favor the development of an abundant microscopic fauna, and therefore to provide a rich field for predacious activity.

While for the present the relationships of *Pedilospora* to other established genera in the Mucedinaceae-Staurosporae remain conjectural, there can be no reasonable doubt that *P. dactylopaga* is a close relative of the nema-capturing form having broad conidia with four divergent lobes that was figured earlier (4: Fig. 9, A, C). In mycelial as in sporulating habit, both in pure and in mixed cultures, the similarity between the two forms is unmistakable. Through further comparison the similarity is seen to extend to the delicate nema-capturing fungus figured in another publication (6: Fig. 16) and later discussed (7) as a species of *Monacrosporium,* the conidia of which, it may be noted here, are occasionally distally bifurcate in a manner suggestive of *Pedilospora.* Evidently *P. dactylopaga* and presumably also its three previously described congeners, might be regarded as having been derived through modification of the narrow-spored type of *Monacrosporium.* Likewise the predacious form with regularly broad quadrilobate conidia could be looked upon as derived from the wide-spored type of *Monacrosporium* represented, for example, in the nema-capturing fungus (4: Fig. 7) apparently first described by Grove (9) as *Dactylella ellipsospora* and later by Bubák (1) as *M. leporinum.* The latter fungus shows such close correspondence in morphology and predacious character to the loosely capitate nema-capturing form (4: Fig. 6) identified (7) as *Dactylaria candida* (Nees) Sacc., that an intimate natural relationship is sufficiently obvious. Equally evident from the many conspicuous resemblances would seem a close relationship of *D. candida* to some loosely capitate, monocephalous, long-spored species of *Arthrobotrys* (4: Fig. 4; 5: Fig. 13); and through them to some compactly capitate, mostly monocephalous shorter-spored species of *Arthrobotrys* (4: Figs. 2, 3), and finally to the densely capitate, short-spored, repeatedly nodose

A. oligospora Fres. In fine, the fungus herein described as new is to be reckoned among the group of intimately interrelated predacious Hyphomycetes exemplified in the last-named species, whose ready appearance on decaying organic substrata has helped to make its remarkable conidial apparatus familiar to mycologists everywhere.

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BOTANY.—*The dental plant of the Citará Indians in Colombia.*[1] W. Andrew Archer. (Communicated by E. P. Killip.)

In March, April, and May of 1931 a visit was made by the author to the Intendencia del Chocó, an area in northwestern Colombia but slightly known scientifically, for the purpose of collecting herbarium material.

In the vicinity of Quibdó, the capital of the Chocó, lives the Citará tribe of Indians, who are noted for their jet black teeth, a condition which is produced by chewing the young shoots of a liana. The plant is known to the Indians as "querá," or "quedá," these terms being derivatives of the word *quidai*, meaning tooth.

The use of the "querá" plant is an integral part of the life of these Indians, just as the use of a toothbrush and dental paste is a part of American hygiene. The Citará children are taught to chew the plant until a complete blackening of the teeth occurs, but after that time

[1] Received May 28, 1934. Much credit is due Sr. Rudolfo Castro of Quibdó who rendered great service in securing data and flowering material of the plant.

the plant is used only occasionally, or on the average of every six months, to restore the worn spots in the black film. Whether or not this black film actually prevents caries is, of course, a matter to be demonstrated under proper scientific conditions.

It is not known definitely how extensive is this practice, but according to reports the Indians of the Urabá section of Colombia, along the Caribbean Sea, also have black teeth. It is said that excavated ancient graves in the region yield skulls with blackened well-preserved teeth. Mr. Guillermo Klug, of Iquitos, Peru, has recently sent the National Museum specimens of *Neea parviflora* Poepp. & Endl., with the note that it is used by the Indians of the Putumayo and Caquetá regions as a dental preservative, having the same blackening effect on the teeth. This plant is called by the natives "yana múco."

The Citará Indians told the author of another plant which they used in the same manner and for the same purpose as "querá," but unfortunately no material was seen. Robledo mentions[2] a species of *Manettia* as a tooth preservative in Antioquia, but the source of his information is not known.

The author's collections of "querá" were submitted to Mr. Paul C. Standley, of the Field Museum of Natural History, who recognized them as representing an undescribed species of *Schradera,* of the Rubiaceae. Mr. Standley has supplied the following technical description of the species:

Schradera marginalis Standl., sp. nov.

Frutex alte scandens 3–10 m. altus omnino glaber, ramulis crassis olivaceis obtuse tetragonis, internodiis elongatis; stipulae caducae ovali-obovatae 2 cm. longae 1 cm. latae apice rotundatae; folia satis magna opposita coriaceo-membranacea petiolata, petiolo crassiusculo 1–2 cm. longo; lamina oblongo-ovalis vel elliptica 11–16 cm. longa 5.5–9 cm. lata apice abrupte acuta vel breviter acuminata, acumine triangulari acutiusculo, basi late rotundata vel obtusa, supra fusco-olivacea, costa venisque manifestis sed non elevatis, subtus fere concolor, costa crassa elevata, nervis lateralibus utroque latere ca. 13 prominentibus angulo lato divergentibus subcurvis ante marginem in nervum collectivum fere regularem conjunctis, nervis intermediis minus conspicuis parallelis interpositis, nervulis obsoletis; inflorescentia terminalis capitata pedunculo crasso recto 14 cm. longo stipitata dense multiflora 3 cm. lata; involucrum breve truncatum 4–5 mm. tantum altum fere 2 cm. latum, floribus sessilibus; hypanthium anguste urbinatum 4–5 mm. longum glabrum, calyce aequilongo truncato; corolla extus glabra, tubo cylindraceo superne vix dilatato intus piloso 8–10 mm. longo 2.2 mm. diam., lobis 4–5 oblongo-ellipticis obtusis patentibus intus dense papillosis; filamenta brevia, antheris oblongo-linearibus 6 mm. longis; stigmata 2 lineari-oblonga 2.3 mm. longa.

[2] Emilio Robledo. Botánica Médica (Medellín) p. 357. 1924.

Type in the Field Mus. Nat. Hist. no. 642,439, collected at the headwaters of Río Tutunendo, east of Quibdó, Intendencia del Chocó, May, 1931, *W. A. Archer* 2204. Represented also by *Archer* 1951, from La Concepción, 15 km. east of Quibdó.

"Flowers 4–5 parted, green below, waxy white above, opening one by one in each head." Among the South American species of *Schradera* this is easy to recognize because the nerves are united to form a nearly regular collective nerve remote from the margin. The leaves are larger than in most species of the genus.

ZOOLOGY.—*Notes on fossil and recent Bryozoa.*[1] R. S. BASSLER, U. S. National Museum.

In his presidential address[2] delivered at the anniversary meeting of the Linnaean Society of London, May 28, 1931, Sir Sydney S. Harmer discussed rather severely the taxonomic studies on fossil and recent Bryozoa by Mr. F. Canu and myself.[3] His criticism is meant kindly and is well founded in some cases so that a reply would not be necessary if our volumes were consulted only by the bryozoan specialist. As we have compiled our works for the beginner in the science and general student, who are not so conversant with the subject, Mr. Canu and I felt that an answer, or at least an explanation of the circumstances concerning their preparation, should be forthcoming. Mr. Canu wished me to write a reply and expected to furnish me with notes, but his lamented death in February of 1932 prevented this.

At this point I should state for the benefit of the non-specialist that the fossil and recent Bryozoa have suffered from nomenclatorial troubles perhaps more than any other group of animals or plants, and as a result generic synonyms abound. The criteria for classification have changed from time to time and new genera have accordingly been proposed by one generation only to be discarded by the next. One celebrated case is that of D'Orbigny, the French naturalist of the nineteenth century, who based many bryozoan genera upon method of growth, a unilamellar form being distinct from a multilamellar one and both of these again different from the bifoliate zoarium, even though experience shows that all three styles of growth forms can exist in the same genus and even in the same species. The subject is further complicated by the failure of many of the earlier authors to cite a genotype.

Comparatively little work had been done upon the Post-Paleozoic

[1] Published by permission of the Secretary of the Smithsonian Institution. Received May 1, 1934.

[2] Proc. Linnaean Soc. London Sess. 143, 1930–31, pt, 8, pp. 113–168.

[3] *North American Early Tertiary Bryozoa.* Bull. 106, U.S. National Museum. 1920.

Bryozoa of North America up to the time Mr. Canu and I took up their study at the request of the U. S. Geological Survey and the Smithsonian Institution, particularly to secure the stratigraphic data that it was believed these organisms would furnish. The opportunity to publish several works upon the subject was seized by us as a means not only of making the faunal and stratigraphic information known, but also of revising as many genera as possible and presenting the essential features of each as worked out by previous authors and ourselves. At this point it should be stated that Mr. Canu's knowledge of English was rather slight and mine of French even less. Much of our manuscript was written in French, and in our earlier works there was always a danger that the exact meaning was not properly translated into English. Practically all of our work also was done with us separated by the Atlantic, so that again errors could creep in. Differences of opinion between us, particularly as to the recognition of genera and the application of the rules of nomenclature, for the same reason could not be thrashed out thoroughly and our results sometimes had to be a matter of compromise. For example, the type species of a genus in which the nature of the ovicell is the most essential generic character may not have shown an ovicell. In such cases Mr. Canu preferred to use such a generic name for the reception of species of that particular group which could not be more closely classified. In case the ovicells were later discovered, the question arose whether the genus should become valid dating from its original author or from the time its real definition was published.

Previous to Dr. Harmer's review, a vigorous statement against our methods of classification of the Cyclostomata was presented by Dr. Folke Borge in his academical dissertation of 1926, where after quoting us to the effect that "a natural classification can be built up by a study of the physiologic functions of the organs," he states that following such a principle the fishes and whales would belong to the same group. Dr. Harmer also writes at length concerning this, but a little tolerance on the part of both would certainly have led them to add the understood words "in the same group of organisms." Mr. Canu and I have probably not used the word physiology as carefully as we should, but in our minds physiology deals with the organic functions or vital phenomena of the living being and has an effect upon the anatomy or structure of the organism which in turn gives rise to its form or morphology. The physiological processes are certainly reflected in the anatomy and morphology. For example, in the Bryozoa, calcification of the walls producing the variously marked

cell surfaces upon which species and genera were founded in former times, is surely the result of a deposit of the organism itself, in other words, a physiological effect. Likewise, the form of the aperture, a purely morphological structure, is determined by the operation of the hydrostatic system and extrusion of the polypide, both certainly physiological in nature. I think, therefore, this criticism is far fetched and beside the point.

Again, we were not distressed when Dr. Harmer observed that "the physiology of Canu and Bassler is not that of observation and experiment, but that it is a physiology of inference." It is true that we were unable to review and digest every published observation, but we thought it our duty as paleontologists to try to resurrect the fossils by inferring the meaning of their characters from a study of recent forms. Without such inferences it is impossible ever to hope to build up a natural classification of fossil forms. Here again I should state that in some instances in stating our deductions or so-called inferences we have failed to add the words "in our opinion," but that surely should be evident to the tolerant reader. I am sorry that we laid stress upon the larval characters for the establishment of families, for as Dr. Harmer says, "that was singularly unfortunate." As a matter of fact, our family classification is based upon more information than the larvae and we only hoped that in time the larval characters would give the final distinguishing feature. I also regret that the two new suborders Hexapogona and Pentapogona were proposed; the latter at the last moment in the course of our 1927 work. The Mamilloporidae and five related families classified in the latter suborder certainly form a division distinct from the other two suborders, the Anasca and Ascophora of the Cheilostomata, but I would not wish to retain Pentapogona as a term for the last two.

Our critics have stated that often we did not follow the rules of nomenclature in our treatment of old, poorly defined, or otherwise unrecognizable genera. Dr. A. M. Waters, the most eminent of all bryozoologists, has repeatedly shown how impracticable it is to revert to old genera based on characters now known to be valueless. Dr. Harmer too has occasionally dropped generic names which, quite correctly in my estimation, he thought would be disadvantageous to the science to retain. Following such authorities, Mr. Canu and I tried to use common sense in nomenclatorial matters, but now after reviewing the entire field and completing the bryozoan chapter for the Fossilium Catalogus, I have to admit that if stability is to be maintained the rules must be followed no matter how illogical they

seem or how silly or unjust the effect. Many genera which by common consent have been dropped must now be recognized and redefined with no basis other than that of some obscure name selected as the genotype or occurring in the original list of species. I have followed this course in the Fossilium Catalogus and I trust that the foregoing remarks will explain our nomenclatorial heresies of the past. The changes made by this procedure will sadden the hearts of the older students, but the bryozoologists of the future can readily adapt themselves to the new arrangements. For example, the oft quoted Paleozoic genera *Fenestella* and *Monticulipora* must now go by the board for good reasons and many little known names now become valid. Some of these generic and other changes and new names for some preoccupied species are indicated in the following notes.

NEW GENERIC AND SPECIFIC NAMES

Chiastosella (Canu and Bassler) new genus (Cheilostomata, family Schizoporellidae). The ovicell is hyperstomial, not closed by the operculum; its external portion is surrounded by a punctate ectooecium more or less developed, and by an endooecium adorned with small pores arranged radially. The aperture bears on its proximal border a narrow rectangular sinus; the peristome bears distal spines. The frontal is a pleurocyst bordered by a double row at least of areolar pores. It bears two long, thin zooecial avicularia transversely oriented exteriorily.

Genotype.—Schizoporella daedala MacGillivray, 1882, in McCoy, Prod. Zool. Victoria, dec. **14**: 146, *pl. 138, fig. 4*. Recent of Australia.

Codonellina new name (Cheilostomata, family Smittinidae). Proposed to replace *Codonella* Canu and Bassler, 1927, preoccupied by Haeckel, 1873.

Fistuliphragma new genus (Cyclostomata, family Fistuliporidae). This new genus, based upon a common, ramose Devonian species, differs from typical *Fistulipora* in that hemiphragms or semidiaphragms are developed in the zooecial tubes.

Genotype.—Fistulipora spinulifera Rominger, 1866, Proc. Acad. Nat. Sci. Philadelphia, p. 121. Devonian (Traverse group) of Michigan.

Hippomonavella (Canu and Bassler) new genus (Cheilostomata, family Schizoporellidae). The ovicell is hyperstomial. The frontal is a pleurocyst surrounded by a row of areolar pores. The aperture bears two cardelles more or less median. In front of the aperture there is an oral avicularium placed on the median axis of the zöoecium.

Genotype.—Lepralia praeclara MacGillivray, 1895, Trans. Roy. Soc. Victoria 4: 73. Tertiary of Australia. *Lepralia radiata* Maplestone, 1901 and *Lepralia elongata* MacGillivray, 1895, also belong to this new genus.

HIPPOPORELLA Canu, 1917 (Cheilostomata, family Schizoporellidae). As pointed out by Miss Hasting in 1930, this genus created by Mr. Canu in 1917 with *Lepralia hippopus* as the genotype, has suffered some vicissitudes. Forgetting the original note in which it first appeared, we introduced the same name as a new genus in 1920 with a fossil species *H. perforata* as the genotype and further complicated the matter by naming *Hippoponella* new genus with *L. hippopus* as its genotype. Our only excuse is that at that time we were involved in the great mass of our 1920 work and mistakes would

creep in. Suffice it to say that *Hippoponella* becomes a synonym of *Hipporella* Canu, 1917, and *Hippoporella* Canu and Bassler, 1920, must be dropped as a homonym.

Monticuliporella new name (Order Trepostomata). Proposed for *Monticulipora* D'Orbigny, 1850 and subsequent authors (not D'Orbigny, 1849).

Genotype.—Monticulipora mammulata D'Orbigny, 1850 (not *Monticulipora* D'Orbigny, 1849, Rev. Mag. Zool., ser. 2, vol. **1**: 503). In founding *Monticulipora* in 1849, D'Orbigny clearly states the genotype as *Ceriopora pustulosa* Michelin, 1846, a synonym of the genotype of *Ceriocava* of the family Ceriocavidae (Cyclostomata). *Ceriocava* thus becomes a synonym of *Monticulipora* and Ceriocavidae of the Monticuliporidae. For the reception of *Monticuliporella* and allied genera of the Trepostomata, the family Prasoporidae proposed by Simpson in 1897 is available.

Pachythecella new name (Cheilostomata, family Porinidae). Proposed for *Pachytheca* Canu, 1913, preoccupied by Schlüter, 1885.

Semicytella new genus (Cyclostomata, family Cytisidae). Proposed for *Semicytis* Canu and Bassler, 1922, Proc. U.S. Nat. Mus. **61**: 74.

Genotype.—Semicytis disparilis D'Orbigny, 1850 (not *Semicytis* D'Orbigny, 1854, Bry. Cret., p. 1048. Genotype (selected by Gregory, 1909) *Osculipora rugosa* D'Orbigny, 1850, a synonym of *Desmepora* Lonsdale, 1850.)

Smittinella (Canu and Bassler) new genus (Cheilostomata, family Smittinidae). The ovicell is hyperstomial, not closed by the operculum; it opens into a peristomie. The aperture bears a lyrule and two cardelles. The peristome is indented by a sinus or bears a spiramen when it is complete. The frontal is a tremocyst in which the number of pores depends on the zooecial width. A large zoarial avicularium can be found occasionally on the longitudinal axis of the zooecium.

Genotype.—Eschara tatei Tenison-Woods, 1876, Proc. Roy. Soc. New South Wales **10**: 149, *fig. 3*. Tertiary. of Australia. This genus differs from *Smittina* in that the proximal sinus of the peristomice is completely covered by the peristome which is then pierced by a spiramen.

Tubitrabecularia (Canu and Bassler) new genus (Cheilostomata, family Tubucellariidae). Tubucellariidae in which the zooecial frontal is an olocyst. The peristomie is strengthened by a trabecular net-work supporting a more or less thickened epicalcification. The ovicell is peristomial. Exterior aspect of the zooecia irregular and quite different from the true zooecial form observed in the interior. Ascopore visible with difficulty at the exterior but clearly seen in the interior.

Genotype.—Tubitrabecularia (*Eschara*) *elevata* Tenison-Woods, 1876, Trans. Roy. Soc. New South Wales **10**: 2, *fig. 10*. Tertiary of Australia.

Centronea americana new name. Proposed for *Centronea micropora* Canu and Bassler, 1920 (not Reuss) of the Eocene of North Carolina. The American species is more robust and has larger micrometric dimensions.

Lagenipora lacunosa new name. Proposed for *Lagenipora verrucosa* Canu and Bassler, 1930, Proc. U.S. Nat. Mus. **76**: 35, *pl. 6, fig. 1* (Galapagos Islands), not *Lagenipora verrucosa* Canu and Bassler, 1928, Proc. U.S. Nat. Mus. **72**: 137, *pl. 21, figs. 5–8* (Gulf of Mexico).

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

U. S. Department of Agriculture.—Drought-resistant grasses, to be used in rebuilding the depleted rangelands of the West, will be sought in central Asia by an expedition of the U.S. Department of Agriculture. On the edge of the Gobi Desert there are great natural grasslands, which have been pastured for thousands of years by nomad tribes, without any sign of exhaustion. In this region the temperature ranges from 100 degrees Fahrenheit in the summer to 40 degrees below zero in the winter, and severe droughts are frequent. Yet the grasses survive, and the herds of livestock and game thrive on them. The leader of the expedition will be NICHOLAS ROERICH, veteran explorer of interior Asia, from Kashmir to the Altai mountains. With him will be his son, GEORGE ROERICH, an expert in Central Asiatic languages, and two Bureau of Plant Industry agrostologists, H. G. MACMILLAN and J. L. STEPHENS.

The drought is charged with guilt in the 66 per cent increase in forest fires for 1934 over the average for three years. If the number of fires increases at the same rate throughout this year the total number will exceed the total of 140,722 fires recorded for 1933. The area burned last year was 43,889,820 acres, with a total damage, estimated as accurately as possible by the Forest Service, at $60,274,960.

The unparalleled drought in the Midwest, soon to enter its fifth month, is showing up in the water levels of the great rivers—the Mississippi, the Missouri, the Arkansas and the Red, which are approaching new low marks at many stations. The Great Lakes also reflect the dry spell in lower levels. Only Lake Superior is higher than the ten-year June average.

Seeds that refuse to sprout when planted can be roused from their dormancy by first soaking them and then exposing them to light for a short time—in many cases as little as a few seconds. L. H. FLINT has discovered this in extensive experiments on lettuce seeds, and in less elaborate tests on lespedeza, a clover-like forage plant important in the South, and on the weeds, mullein and curled dock. It is only the longer wave lengths of light, Dr. Flint discovered, that have this stimulating power. Seeds exposed to light at the blue-violet end of the spectrum refused to germinate. Even seeds that had been given the stimulating treatment with the longer wave lengths at the red end, and then were exposed to blue or green light, would not sprout. Apparently something in the shorter wave length rays reverses the process set up by the longer ones.

Organization of new Division of Game Management.—The recently created Division of Game Management in the Bureau of Biological Survey will be organized as follows, under STANLEY P. YOUNG, in charge: In the new set-up, four sections will have care of the four distinct branches of the divisional operations. W. E. CROUCH, of the old Division of Predatory Animal and Rodent Control, will head the section dealing with the activities of law-enforcement officials and supervisors of game preserves and bird refuges. ALBERT M. DAY, also of the old Predatory Animal and Rodent Control Division, will head the section on the control of injurious mammals. F. P. CALLAGHAN, of the old Division of Game and Bird Conservation, will head the section dealing with the prosecution of violators of Federal migratory-bird laws. R. W. WILLIAMS will head the section dealing with importations of foreign wild species and issuance of Federal permits under laws admin-

istered by the Bureau, as formerly. Eight administrative regions have been established, covering the United States, each to be in charge of a regional director.

U.S. Public Health Service.—During July and August, the U.S. Public Health Service was called upon to concern itself with two serious outbreaks of disease: typhoid fever in several parts of the country, and bacillary dysentery in New York City and New Jersey; although the direct combating of these threatened epidemics was competently taken care of by state and local health authorities. The increase in typhoid appears to have been an indirect consequence of the drought; smaller communities whose normal water supplies failed were compelled to turn to secondary sources, which were in some cases insufficiently safeguarded. An interstate problem arose when several members of a leading circus troupe became ill with typhoid fever. After determining that none of the food handlers connected with the circus were carriers, the Public Health Service decided that the continued travel of the organization did not constitute a danger to public health.

Children's Bureau, U.S. Department of Labor.—In a critical review of child health, 1933–1934, prepared for the Journal of Pediatrics by MARTHA M. ELIOT, director of the child hygiene division of the U.S. Children's Bureau, certain pertinent facts regarding effects of the depression on child health are analyzed and attention is called to steps already taken to attempt to safeguard child health in the future. Quoting reports from official and unofficial sources Dr. ELIOT concludes that "there would seem to be little doubt any more that the depression has been having an adverse effect on the health and nutrition of many of the five or six million of children affected by the lowering of living standards due to unemployment or underemployment," and suggests that since the effects are apparently cumulative, it is likely that they will continue to be felt for a considerable period after the depression has passed, unless more active steps are taken to combat them than are possible with the present limited child-health budgets and relatively low standards of relief still prevalent in many communities.

Office of the Surgeon General, War Department.—The United States Army Medical Department Research Board, which has been functioning in Manila, P.I., for the past 33 years, has been transferred to the Canal Zone, Panama. This step was taken for two reasons: first, it is believed that the activities of the Army will be greatly curtailed in the Philippine Islands in the near future; second, many problems confront the Army stationed in the Panama Canal Zone. Therefore, it is believed that the board should attempt to solve some of these problems at an early date.

During the winter and spring maneuvers, involving 3,000 troopers, atabrine and quinine were used as prophylactic measures against malaria. After a period of three months following maneuvers in the Bataan peninsula no cases of malaria occurred in the experimental batallion. Among the entire 3,000 troops only about 20 cases of malaria in all occurred during and following the maneuver period. These are by far the most encouraging results that have ever been obtained with troops in the field in the Philippine Islands.

National Bureau of Standards.—Studies by MILTON HARRIS indicate that samples of silk fabric if exposed to daylight for four months while enclosed in an evacuated container, have as much tensile strength as they had at the

start. Similar samples of silk exposed to the same light, but in moist oxygen showed a 10 per cent loss of strength in the same time. The increase of the amount of nitrogen in the form of ammonia present in the silk during the chemical deterioration of the fabric by light is further evidence that the reaction is one of oxidation.

A recent study of old newspapers made by B. W. Scribner indicates that the rag fiber paper on which news was printed before 1868 was more resistant. The older newspapers were found to be still in excellent condition. Most of the editions appearing after that date, however, contained a crude ground-wood fiber. They were generally found to be in an advanced state of decay. The resumption in 1927 of printing permanent library editions on paper composed of high-grade fibers will probably preserve some of the later records. Tests showed that satisfactory papers have been developed for this purpose.

A new device for measuring the small amounts of air passing through membranes of such varied nature as cigarette paper, builders' sheathing paper, leather, and food wrappers has been invented by S. T. Carson.

The Bureau has conducted an investigation of a number of "gas savers," "grease absorbers," "burner protectors," and similar appliances that are sold over the doorsill by canvassers. All of the "gas savers," it stated, affected the operation of a satisfactory gas range in such a way as to increase the tendency to form carbon monoxide, which even in very small amounts is injurious to health. The "burner protectors," the report continued, keep the burners clean but do so at the expense of cooking efficiency. None of the water backs tested proved satisfactory while some of them caused the formation of carbon monoxide. "The 'grease absorbers,'" the report states, "should be called grease diffusers, because they merely distribute the grease more uniformly around the kitchen."

William F. Meggers, chief of the spectroscopy section, attended the Spectroscopy Conference at Massachusetts Institute of Technology during the week of July 16–21. Dr. Meggers presented two papers, one on specifications for wave length standards, and the other on measurements of standard wave lengths in the spectra of the noble gases.

Laurinson S. Taylor, in charge of the X-ray laboratory, attended the Third International Congress on Radiology at Zurich, Switzerland.

Hugh L. Dryden, chief of the aerodynamical physics section, attended the Fourth International Congress for Applied Mechanics, at Cambridge, England.

News Briefs

Daily releases of small balloons to carry automatic radio meteorographs into the stratosphere are contemplated. Lt. W. H. Wenstrom of the Signal Corps, U.S. Army, has been making studies at the California Institute of Technology with this object in view.

Extensive repairs are being made on the Washington Monument, which during its 86 years of existence has developed extensive cracks and spalling.

The recent Congress, just before its adjournment, authorized the expenditure of $500,000 for the construction of a thoroughly modern fisheries research ship.

Scattered Indian legends of a tremendously large long-haired animal with a "very big nose" which it used for pulling up trees are being investi-

gated by W. D. Strong of the Bureau of American Ethnology, to sift the possibility of survival of the hairy mammoth into post-pleistocene time, and until human migration into North America had taken place.

An unusually large concentration of earthquakes, seventeen of them in a five-day period ending July 21, was reported by the cooperative agency for collecting seismologic data maintained by the U.S. Coast and Geodetic Survey, the Jesuit Seismological Association and Science Service.

An improved motion picture for aerial combat target practice has been adopted by the U.S. Navy; in appearance and handling weight it closely duplicates an actual machine gun.

The outer atmosphere of Venus contains 10,000 times as much carbon dioxide as is present in the atmosphere at the earth's surface, it is indicated by recent studies by Walter S. Adams and Theodore Dunham, Jr., of the Mt. Wilson Observatory of the Carnegie Institution of Washington.

America's most striking natural wonders are made the basis of the designs of the new National Parks series of postage stamps. The one-cent stamp bears a picture of El Capitan, in Yosemite; the two-cent, a view of the Grand Canyon of Arizona; Mount Rainier appears on the three-cent stamp; the Cliff Palace of Mesa Verde on the four cent; Old Faithful geyser on the five-cent; Crater Lake on the six-cent; Mount Desert, in Acadia National Park, on the seven-cent; the Great White Throne, in Zion National Park, on the eight-cent; Mount Cleveland, in Glacier National Park, on the nine-cent, and a scene in the Great Smoky Mountains on the ten-cent.

Personal Items

General Hugh S. Johnson, chief of the N.R.A., delivered the closing address at the Fourth Annual Economic Conference of Engineers at the Stevens Engineering Camp, Johnsonburg, N.J., on August 19.

J. Bartels, research associate of the Carnegie Institution of Washington and professor at the Förstliche Hochschule, Eberswalde, Germany, arrived in Washington early in August. He will remain at the Department of Terrestrial Magnetism for about three months, engaged on research work in terrestrial magnetism.

On Sept. 1, 1934, O. W. Torreson will succeed J. E. I. Cairns as observer-in-charge of the Huancayo Magnetic Observatory in Peru. The latter, having completed his three-year term of service at the Observatory, will return to Washington. W. E. Scott has been appointed an observer on the staff of the Observatory and will leave Washington for Peru on Sept. 1.

Alice C. Evans of the National Institute of Health discussed certain biological and chemical aspects of the bacteriophage in a recent issue of *Science.*

Robert S. Campbell, formerly in charge of the Jornada Experimental Range of the Southwestern Forest and Range Experiment Station, has been appointed senior conservationist in the division of range research of the U.S. Forest Service, with headquarters in Washington.

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JOURNAL

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GEOPHYSICS.—*Earthquakes associated with the 1933 eruption of Mauna Loa, Hawaii.*[1] Austin E. Jones, Geological Survey. (Communicated by T. A. Jaggar.)

A relation between volcanic outbreaks and accompanying earthquakes has long been noted. In this connection there is presented here a series of 77 earthquake locations recorded during the 11 months preceding the Mauna Loa eruption of December 2, 1933, followed by 19 locations recorded during and after the outbreak.

During the year 1933, a double network of seismograph stations was maintained by the U. S. Geological Survey and the Hawaiian Volcano Research Association as follows:

TABLE 1.—Seismograph Stations in Hawaii in 1933.

Name	Map symbol	Name	Map symbol
Hawaiian Volcano Observatory	V	Hilo[a]	H
Uwekahuna	U	Kealakekua[a]	K
Halemaumau....(Pit)	P	Waikii	W

[a] Two of these stations were kept going by volunteers.

The main station of this group (V) recorded 232 earthquakes, about 1,800 spasmodic tremors, and about 2,300 minutes of harmonic tremor. Spasmodic tremors are in many cases very small records of the secondary waves of small local shocks and in other cases may have been generated by moving lava. The harmonic or continuous volcanic tremor usually accompanies eruptions and is thought to be generated by the flowing lava, much as similar vibrations elsewhere are generated by water-falls.

About 40 per cent or 96 earthquakes were located. Those in Kilauea crater have been left out to avoid crowding. In July 1933, 35 quakes

[1] Published by permission of the Director of the U. S. Geological Survey. Received July 6, 1934.

and tremors were located in and about Kilauea crater. About half of the located earthquakes were felt. It is rarely possible to locate an earthquake in Hawaii by drawing isoseismals because only the fringe of the island below 4,000 feet elevation is settled.

The earthquakes are located by distances from the several stations shown on the map. The stations used in finding the epicenter are listed in the table for each numbered earthquake. Poor epicenters are located with the aid of only one or two stations. Good epicenters are located from three or four stations.

Depths less than 10 kilometers are not listed. The errors in depth are large when near the surface of the earth and far from a station. It is believed that other depths are too small. They should indicate any tendency of earthquakes to get progressively shallower or deeper.

The distances from each station are found by measuring the "duration of the preliminary"[2] for each earthquake from each station record. The laws connecting the S–P time interval and the distance as found for the Hawaiian islands are:

$$S_g - P_g; \ldots\ldots \quad t_g = 5.7 + 0.143\Delta - 5.7e^{-0.3\Delta}$$
$$S^* - P^*; \ldots\ldots \quad t^* = 1.7 + 0.098\Delta$$
$$S_n - P_n; \ldots\ldots \quad t_n = 0.3 + 0.092\Delta$$

where t = time in seconds and Δ = distance in kilometers.[3] These distances are first used on a mechanical focus finder,[4] which consists of an inverted relief map with distances on strings from each station. The epicenter located in this way is checked by a graphical method,[5] and the epicenter plotted on the map. In 1932 one focus was located that appeared deeper than any in the table, namely 70 kilometers. A slight tendency for the quakes to get progressively shallower up to the time of the eruption was noted.

Approximately one seventh of the located epicenters were under the sea, usually on the submarine slopes of the island. The first one in the table occurred in 15,000 feet of water at the SE edge of a 6,000 foot rise in the sea floor. Numbers 0, 2A and 61 occurred where the sea is 16,000 to 18,000 feet deep.[6] Approximately one third of the epicenters were on the quiescent volcanoes of Hualalai, Mauna Kea,

[2] S-P interval in seconds.

[3] Unpublished manuscript.

[4] Volcano Letter No. 351, published by the Hawaiian Volcano Research Association.

[5] Physics of the Earth, Seismology. National Research Council. p. 162.

[6] It is interesting to note that these earthquakes originating under the sea bottom, where the island materials consisting of piled-up lava flows are very thin or even lacking, give rise to multiple P and S waves. This indicates a layered condition of the sea bottom near the island chain. The numbers of P and S waves found in each of the above four quakes is 3, 2, 3, and 4.

and Kohala. The remainder were on the active volcanoes of Kilauea and Mauna Loa.

A small number of the located earthquakes of 1933 occurred on the known island rifts. It is to be expected that the rifts would show greater seismic activity in the neighborhood of volcanic centers.

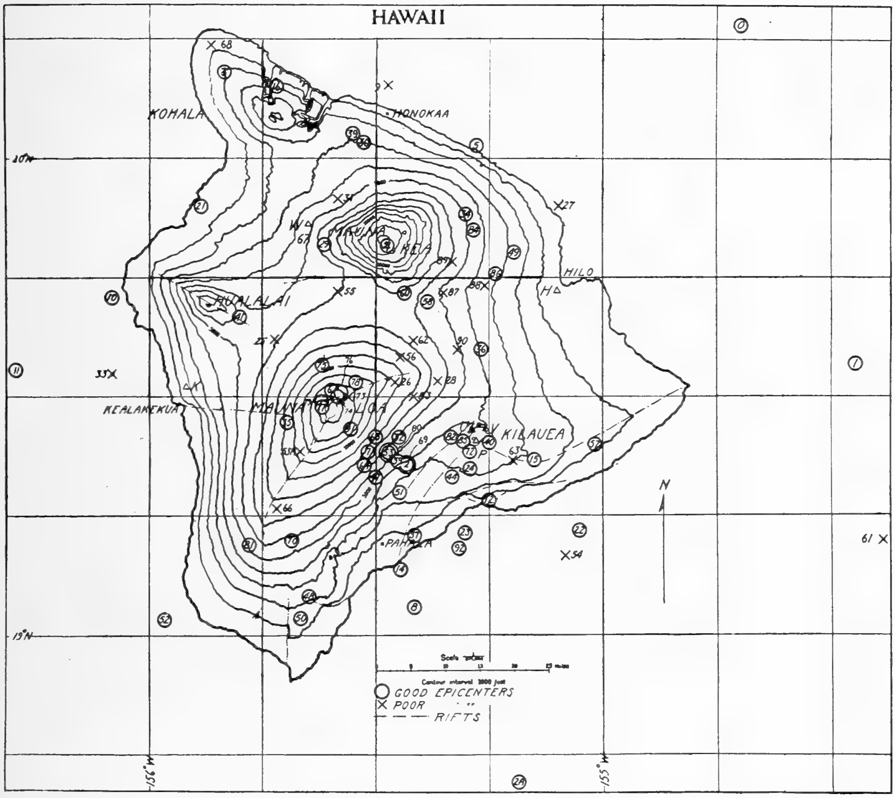

Fig. 1—Map of the Island of Hawaii giving location of recorded earthquakes preceding and following the 1933 eruption of Mauna Loa.

Groups of epicenters fell in lines to the SE, NE, and N of the summit crater of Mauna Loa. These lines of epicenters may define rifts. No topographic features have been found to indicate that these are rift lines.

A number of earthquakes occurred within craters. More than 40 small shocks, chiefly instrumental, were recorded from Kilauea crater during the year. At times these crater shocks definitely precede and accompany eruptions. More often they are caused by movements deep in the volcano. These movements are sometimes accompanied by surface changes such as opening of cracks and changes of tilt.

TABLE 2.—EARTHQUAKES PRECEDING AND FOLLOWING THE 1933 ERUPTION OF MAUNA LOA.

Map Nos.	Date	Lat N.	Long. W.	Recording Stations	Depth km.	Remarks
		° ′	° ′			
	Jan. 11	19	158	VHKW		Not felt
0	Jan. 11	20 17	154 42	VHK		Not felt
1	Jan. 31	19 34	154 27	VH		Not felt
2	Feb. 10	19 22	155 26	VHK	53	
2A	Feb. 4	18 42	155 11	VHK		Felt by few in scattered positions
3	Feb. 13	20 11	155 50	VHKW		Not felt
4	Feb. 16	19 49	155 28	VHKW	37	Felt at Honokaa
5	Feb. 18	20 02	155 17	VHW	12	Felt at Honokaa
6	Feb. 18	19 31	155 36	BKW	57	Not felt
7	Feb. 21	19 23	155 31	VHKW	28	Not felt
8	Feb. 22	19 03	155 25	VHK		Not felt
9	Feb. 27			V		Felt at Honokaa
10	Feb. 28	19 43	156 05	VK		Not felt
11	Mar. 8	19 33	156 18	KW		Not felt
12	Mar. 8	19 17	155 15	VH	10	Not felt
13	Mar. 8			V		Near no. 12
14	Mar. 9	19 08	155 27	VHW		Felt at Pahala
15	Mar. 25	19 22	155 09	VHK	13	Not felt
16	Mar. 28	20 09	155 43	VHKW		Felt in north of Island
17–20						Near or in Kilauea crater, not felt.
21	Apr. 9	19 54	155 53	KWVH	23	Not felt
22	Apr. 16	19 13	155 03	VWHK	37	Felt lightly in Hilo
23	Apr. 30	19 13	155 18	VHKW	19	Not felt
24	Apr. 30	19 21	155 17	VHKW	33	Felt near Volcano, V.
25	May 2	19 37	155 43	VHKW		Approximate location, not felt
26	May 9	19 32	155 27	VHKW		Felt at Volcano and near epicenter
27	May 17	19 54	155 06	VHW		Felt near epicenter
28	May 20	19 32	155 22	VW		Not felt
29	May 24	19 49	155 37	VHKW		Felt at W & Honokaa
30	May 24	20 02	155 31	VHW		Felt in Honokaa
31	May 25	19 55	155 35	HKW		Not felt
32	May 27	19 25	155 27	VHKW		Felt lightly
33	May 28	19 33	156 05	VK		Felt near epicenter
34	June 7	19 53	155 28	VHW		Not felt
35	June 9	19 27	155 42	VHK	10	Slopped water from tanks near epicenter
36	June 15	19 36	155 16	VHK		Not felt
37	June 19	19 13	155 25	VHKW	10	Not felt
38	June 20			V		Near or in Kilauea crater
39	June 22	20 03	155 33	VHKW	11	Felt near epicenter
40	June 25	19 24	155 15	VUP		Not felt
41	June 29	19 40	155 48	VHKW		Felt lightly over Island
42	July 2			V		In Kilauea crater, not felt
43	July 14			V		In Kilauea crater, not felt

TABLE 2.—*Continued.*

Map No.	Date	Lat. N.	Long. W.	Recording Stations	Depth km.	Remarks
		° ′	° ′			
44	July 19	19 20	155 20	VHW	40	Felt in Hilo
45	July 20			V		In Kilauea crater, not felt
46	July 22			V		In Kilauea crater, not felt
47	July 31	19 20	155 30	VHK	16	Felt sharply near epicenter
48	Aug. 7	19 05	155 39	VK		Felt near epicenter
49	Aug. 31	19 48	155 12	VHKW	39	Not felt
50	Sept. 2	19 02	155 40	VHK		Not felt
51	Sept. 7	19 18	155 27	VHK	45	Felt
52	Sept. 11	19 02	155 58	VHK		Not felt
53	Sept. 11	19 23	155 28	VHK	11	Felt near epicenter
53A	Sept. 14	19 23	155 40	VK		Not felt
54	Sept. 14	19 10	155 05	VH		Not felt
55	Sept. 16	19 43	155 35	VH		Not felt
56	Sept. 20	19 35	155 27	VH		Not felt
57	Sept. 21	19 24	155 01	VPU		Not felt
58	Sept. 26	19 42	155 23	VHK	11	Felt slightly
59	Sept. 28	19 22	155 27	VHK	15	Felt near epicenter
60	Sept. 30	19 43	155 26	VKW		Not felt
61	Oct. 13	19 12	154 23	VH		Felt slightly in Hilo
62	Oct. 19	19 37	155 25	VHKW	15	Felt slightly in Hilo
63	Oct. 20	19 22	155 12	P		Felt near epicenter
64	Oct. 21	19 21	155 31	VHK		Felt generally
65	Oct. 21	19 25	155 30	VHK	15	Felt generally
66	Nov. 10	19 16	155 43	VK		Felt in district to NW
67	Nov. 13	19 50?	155 40?	W		Felt at Waikii
68	Nov. 25	20 15?	155 50?	VW		Felt in Kohala
69	Nov. 25	19 22	155 26	VHK		Not felt
70	Nov. 26	19 12	155 41	VHK		Not felt
71	Nov. 28	19 25	155 16	VUP		In Kilauea crater
72	Nov. 30	19 23	155 17	VUP		Not felt
73	Dec. 1	19 30	155 33	VH		Not felt
74	Dec. 2	19 30	155 35	VHKW	14	Felt
75		19 34	155 37	VW		Not felt
76		19 30.5	155 34.5	VHKW		Not felt
77		19 29	155 37	VKW		Felt
78		19 32	155 32.5	VHKW		Felt
79		19 29.5	155 37	VKW		Not felt
80	Dec. 2	19 23	155 28	VHKW		Not felt
81	Dec. 7	19 12	155 46.5	VKW		Felt near epicenter
82	Dec. 12	19 25	155 20	VPU	7	Not felt
83	Dec. 14	19 30	155 25	VHKW	25	Felt near Kilauea
84	Dec. 20	19 51	155 17	VHW	5	Not felt
85	Dec. 20	19 24.5	155 18	VUP		Not felt
86	Dec. 20	19 45.5	155 14	VHW		Not felt
87	Dec. 27	19 43	155 21	VH		Felt near epicenter
88	Dec. 27	19 44	155 15.5	VH		Felt near epicenter
89	Dec. 27	19 47	155 20	VH		Felt near epicenter
90	Dec. 27	19 36	155 19	VH		Felt near Kilauea
91	Dec. 30	19 26	155 33	VHKW	17	Felt in Hilo
92	Dec. 31	19 11	155 19	VHW		Not felt

Earthquakes have been reported felt by parties on Mauna Loa, usually while in or near the crater or near the rifts. These quakes often give small instrumental records or none at all. It may be inferred that Mauna Loa earthquakes equal if not surpass the numbers recorded from Kilauea.

The Mauna Loa eruption of 1914[7] was preceded, during two months, by earthquakes more than 20 kilometers away from the Observatory. In October 1933 a similar seismic disturbance occurred. There was a notable increase in the earthquakes in the range of 20 to 100 kilometers. This swarm of earthquakes preceded the outbreak of Mauna Loa by six weeks.

Nearly coincident with the outbreak and probably caused by it, were 13 quakes recorded in slightly more than two hours. Only three of these were felt as far away as Hilo. A party staying at the rest house on the Mauna Loa northeast rift, elevation 10,000 feet, reported that the shocks were quite alarming. Of the 13 shocks, six were large enough and well enough recorded at all stations to be located. The depth of the first was 14 kilometers. The measurements suggest that the following quake (No. 75) was 6 kilometers deep, the next two were near sea level or above, no. 78 was at 4 kilometers depth (possibly above as the elevation of the mountain is 4.2 kilometers), and no. 79 was at 9 kilometers depth. It should be remembered that there were seven smaller unlocatable shocks at this time. One preceded and six followed the six located shocks. It is probable that they were of such high focus as not to record completely at any other station. It is quite likely that they were located in the southeast section of the crater of Mokauweoweo, as the located shocks do not quite coincide with the eruption fissures.

During and after the eruption the known seismic activity migrated away from the volcanic center, the direction being SW, SE, E, and NE. The larger numbers of epicenters were on the NE rift of Mauna Loa and to the east of Mauna Kea.

A list of the recorded earthquakes is given in Table 2 and their location noted on the map (Fig. 1).

[7] H. O. Wood. *The seismic prelude to the 1914 eruption of Mauna Loa.* Bull. Seis. Soc. **5**, No. 1. 1915.

GEOPHYSICS.—*A note on the elastic properties of rocks.*[1] ROY W. GORANSON, Geophysical Laboratory, Carnegie Institution of Washington.

Variations in the physical and chemical constitution of rocks are found to produce observable changes in their elastic properties. This fact constitutes an important resource in geophysics because the elastic properties of material at depth in the earth can be evaluated from seismologic data if the density is known. When these elastic properties determined within the earth are compared with the known properties of rocks determined from laboratory measurements important information concerning the nature of the material is at once available. However, in order to make such correlations it is assumed that a simplified form of the elastic theory is valid, that rock specimens are representative of the rock body from which they were removed, that elastic data are independent of the method employed, and that the functional relations are sufficiently well known so that laboratory data can be safely extrapolated beyond the experimental pressure limit. It is well known that these assumptions are not fulfilled exactly, but they approximate to the actual conditions in many cases; in other cases they do not. The addition of new data has reopened the problem of reconciling the elastic properties of rocks calculated from seismic data with those obtained from laboratory measurements.

The elastic symmetry of perfectly annealed, homogeneous glass is isotropic, but that of crystals is not isotropic (anisotropic) and varies with the crystalline symmetry. An aggregate of randomly oriented crystalline grains, such as is present in some rocks, should behave isotropically as a whole if no other variables entered into the scheme of things, but an analysis of the experimental results shows that, under certain conditions, to ignore such other variables would lead to serious error because directional variations apart from mere crystallinity have been observed in the same specimen. Even though we assume that the stress-strain relations are calculable by the classical theory of elasticity the mechanics and contributions of such variables are not sufficiently known at present to be evaluated, and so for purposes of calculation in correlating different data, isotropy is generally assumed as an approximation. If such calculations lead to results consistent with other data general experience is that they will be fairly trustworthy, if not, then these variables cannot be neglected.

[1] Received July 24, 1934.

If homogeneity of constitution and isotropy be assumed there are simple functional relations[2a] between the compressibility β or bulk modulus K ($K=1/\beta$), modulus of rigidity R, Young's modulus E, Poisson's ratio σ, the velocity of the distortional wave V_s ($V_s^2=R/\rho$) and the velocity of the compressional wave V_p ($V_p^2-4V_s^2/3=K/\rho$). These relations are such that if the density ρ, and any two of the quantities are known the others can be evaluated.

The actual determination of elastic properties of rocks can be divided into two types, namely, dynamic methods involving adiabatic changes of state and static methods involving isothermal changes of state.[2b]

In the first group fall all data of seismic origin and some few laboratory data at low pressure obtained by setting the specimens into vibration. All other laboratory data have been derived by static methods. F. D. Adams and Coker[3] determined E and σ by measuring the longitudinal compression and lateral extension under unidirectional thrust (mean stress of 350 bars). The Watertown Arsenal[4] has made similar measurements on rock materials. Nagaoka[5] determined E and R by measuring bending and twisting of specimens. Zisman[6] determined E and σ under unidirectional thrust (to a mean stress of 55 bars) and β under hydrostatic pressure (to 700 bars) by measuring changes in linear dimensions. Nagaoka's values of E and R would lead to negative compressibilities, an absurdity. Zisman's values of E and σ are not consistent with his compressibilities. Moreover, his determinations of $\delta=(1/l_0)\partial l/\partial p$ (where l denotes length, l_0 being the initial length, and p the pressure) are not in general equal to $\frac{1}{3}\beta$ which would be true for isotropy. At low pressures rocks cannot therefore be treated a priori as if they were homogeneous isotropic substances.

Because rocks can differ widely not only in mineral composition but also in grain size and orientation, grain boundary bonding, and kind and amount of open spaces (pores, cracks, etc.) it does not seem surprising that inconsistencies occur when different methods are used. If the seismic disturbance as registered on a seismograph represents that portion which has lost the least amount of energy in its

[2] ROY W. GORANSON. *Thermodynamical relations in multi-component systems.* Carnegie Inst. Washington. Publ. 408. 1930: [a] p. 128; [b] p. 122.

[3] F. D. ADAMS and E. G. COKER. *An investigation into the elastic constants of rocks more especially with reference to cubic compressibility.* Carnegie Inst. Washington Publ. 46. 1906.

[4] Watertown Arsenal Report, 1894.

[5] H. NAGAOKA. Phil. Mag. 50: 53. 1900.

[6] W. A. ZISMAN. Proc. Nat. Acad. Sci. 19: 653. 1933.

travel, and therefore must have followed paths of high elasticity, there is present here a type of discrimination entirely lacking in static methods. The inhomogeneities stated above could then give widely different results for static and dynamic methods at low pressures which would become ironed out at high pressures.

Rock composition, grain size, type of bonding, and porosity will be functions of the conditions at the time of formation and so may be more or less uniform over a relatively large area. Open spaces other than pores will depend on the later history of the region and can be extremely localized. The act of removing a specimen for test may contribute by introducing stresses sufficient to open up cracks and loosen the rock structure. If seismic disturbances as registered are propagated along paths of high elasticity and therefore in effect ignore the open spaces, as Zisman concludes from his data, the bulk modulus will be dependent only on the kind of mineral grains, their orientation, and bonding. The mineral grains may be intimately interlocked, touching at only a few points, or separated by a bond of cementing material. A close knit interlocking structure of randomly oriented grains should have elastic properties approaching the mean of the constituent mineral grains whereas the largest deviation should be found in rocks of loosely aggregated grains. This is corroborated by general experience.

The idea that stresses accumulate mainly in the neighborhood of surfaces of discontinuity of physical properties might lead one to consider changes in geometric shape arising from complicated nonhydrostatic internal strains in the neighborhood of such grain contacts. If such effects were noticeable they would show up in linear measurements as hysteresis or as *anisotropic* behavior, but in volume measurements only plastic flow with increase in density (permanent set) occurred. Such an effect would be most apparent in highly compressible heterogeneous materials such as granite.

Zisman has determined the compressibilities of several rocks to pressures of 700 bars by measuring linear changes with pressure and calculating the volume changes from them. In some of his experiments he has made independent sets of measurements on three separate pieces from the same specimen but cut at right angles to each other. Even such precautions do not seem to have been sufficient to give a truly representative compressibility because, with the exception of one specimen in which the feldspar/quartz ratio was highest and therefore by this criterion should have been the most incompressible, his compressibilities of uncovered granites average *less* than the com-

pressibilities calculated from the volume average of the component minerals; this seems hardly probable because the latter represent minimum value curves to which the experimentally determined values approach asymptotically at high pressures. His compressibility value for uncovered Vermont marble is *less* than the compressibility of calcite and in line with his results on granite. He has also made measurements on a rock which he calls dolomite but describes as having 98 per cent calcite; it may have been incorrectly described but if not it should have a compressibility equal to or more than calcite, his actual value of β is about 14 per cent less than that of calcite.

It might be concluded from such results that a very low form of elastic symmetry is present in such rocks and that when they are strained there is involved not only a change in linear dimensions but also a change in angular dimensions. For example, a cube of granite would not remain a cube or even a rectangular parallelopiped, but deform into some non-rectangular configuration. A measure of the compressibility could not then be obtained, in general, from three linear changes at right angles to each other. From Zisman's results, the change in configuration of such rocks should differ enough quantitatively from a simple contraction of the linear elements to be readily apparent. This low form of symmetry, if it exists, must be confined largely to low pressures, at moderate to high pressures there is fair agreement between linear and volume measurements, and between laboratory and seismic data.

There are, however, other effects at low pressures which must first be taken into consideration. Hysteresis, which implies irreversibility in the sequence of states through which the specimen passes is indicated by *elastic afterworking* and *permanent set* in the results of the Watertown Arsenal, Adams and Coker, and Zisman. *Elastic afterworking* is a term used when the strain produced in a specimen under load is not in general independent of time and when the extent of elastic recovery depends on the length of time a strained specimen is free from load. The results of Adams and Coker and of the Watertown Arsenal show clearly that there is an increase in resistance of rock to deformation from repeated loading and unloading of forces. *Permanent set,* generally grouped under plastic effects, is the term used for ultimate deformation, the specimen never returning to its original condition. These all indicate that the instantaneous state of a rock depends not only on the external conditions prevailing at the instant but also on the previous states. The classical theory of elasticity is, moreover, restricted to conditions in which the strain result-

ing from a load disappears on removal of the load, and this necessary condition is violated by the above hysteresis phenomena.

A rock specimen is probably not in the same state of strain as the parent rock body from which it was obtained. The mere separation of the specimen from the parent body can alter its state of strain by a rearrangement and release of accumulated stresses. Some disturbance, generally by impact, also follows from the removal, and strains induced by a force suddenly applied may be twice those induced by the same force applied slowly. These stresses may be sufficient to further complicate the history of the specimen by opening cracks and loosening the rock structure. The strain history of the rock body will not be known because the conditions existing at the time of its formation will not be those of today, and during the intervening time loading and unloading, aided by shearing forces, will have acted to modify the original stress-strain relations. It can generally be assumed, however, that the rock body will be in a *state of ease* for a higher state of strain than the specimen (that is, it can be strained without permanent set to a higher limit of strain). In this connection it is interesting to note that experimental results obtained at high pressure do not exhibit any of these irreversible phenomena. Bridgman observes a linear hysteresis but this is a true elastic hysteresis in which the stress-strain diagram is a closed, reproducible curve.

It is suggested that if the specimen be first seasoned, perhaps repeatedly, at rather high hydrostatic pressure, the experimental results obtained at low pressure would become more reproducible, more amenable to theoretical treatment and probably more representative of the rock body. For this seasoning the specimen should be made impervious to the pressure fluid in order that the pressure may act on the specimen as a whole.

In the high-pressure range Bridgman[7] has determined $\delta=(1/l_0)\partial l/\partial p$ from linear measurements and L. H. Adams[8] and his co-workers $\beta=(1/V_0)\partial V/\partial p$ by obtaining volume changes from piston displacements. It is indicated that at high pressures rocks become more amenable to treatment as isotropic bodies since the compressibility values of Bridgman and of Adams are generally in good agreement.

However, even for high-pressure data a postulation of isotropy can lead to serious error. It has been stated in this article that perfectly annealed homogeneous glass is isotropic but this is not true for strained glass. In order to obtain basalt glass or tachylite it is

[7] P. W. Bridgman. Am. J. Sci. **7**: 81. 1924 (rocks); ibid. **10**: 359. 1925 (tachylite),

[8] L. H. Adams and E. D. Williamson. J. Franklin Inst. **195**: 475. 1923. L. H. Adams and R. E. Gibson. Proc. Nat. Acad. Sci. **12**: 275. 1926 (tachylite).

necessary to cool the melt rapidly because it crystallizes readily. Rapid cooling means steep temperature gradients and this treatment yields a strained glass. Bridgman[7] has determined δ and Adams and Gibson[8] have determined β of Kilauea tachylite in the pressure range of 2 to 12 kilobars. Adams and Gibson's mean value of β at 25°C for this pressure range is 1.45×10^{-6} reciprocal bars. Also, from their residuals, it is apparent that over this range of pressures $\Delta\beta$ is negative and not more than 3 per cent of this value. Bridgman's value of δ at 30°C is 0.45×10^{-6} reciprocal bars to 7350 bars, at pressures above 7350 bars the slope is about the same but *negative*, i.e., the specimen elongates under pressure. On the assumption of isotropy β would be 1.35×10^{-6} reciprocal bars to 7350 bars and then become negative by about the same amount, which of course cannot be true. The reversal point is affected by temperature, which is what we should expect if temperature strains were involved; at 75° there is no reversal, and he finds $\partial\beta/\partial p$, assuming $\Delta\beta=3\Delta\delta$, negative and about 14 per cent of the compressibility at 7 kilobars for the pressure range of 2 to 12 kilobars. But isotropy cannot be assumed here and β is not equal to three times the change of one linear dimension with pressure at any pressure. A representative β from linear dimensions can only be obtained from the measurements along each of the three principal directions of the strained glass. It would seem reasonable then to assume that β and $\partial\beta/\partial p$ obtained from volume measurements, such as those of Adams and Gibson, will be more reliable than from measurements on one linear dimension of such non-isotropic material, and although it is possible that β might decrease more rapidly at higher pressures, there is no a priori reason for such a conclusion. The extrapolations Daly[9] makes of Bridgman's data at 75° could therefore be in error.

Rock specimens sealed so that they do not come in contact with the compression fluid have a much higher compressibility at low pressures than specimens open to and therefore penetrable by the pressure fluid as is indicated by Zisman's measurements. This would be expected because a certain penetration of fluid into the open spaces of the "uncovered" rock specimens would occur and so prevent these cavities from closing under pressure. In sealed specimens the paths of least resistance are the openings in the rock specimen, the first effect of pressure will be to close up these openings and therefore they will contribute less and less to the compressibility of the speci-

[9] R. A. Daly. *Igneous rocks and the depths of the earth.* (McGraw-Hill Book Co., New York, N. Y.) 1933, pp. 189–190.

men as pressure is increased, consequently the measurements at high pressure of sealed and unsealed specimens would approach one another in value, which is what L. H. Adams and Williamson found to be the case. However, anomalous behavior can occur in uncovered rock specimens because, for a certain pressure fluid, a certain range of differential pressures will be needed to fill the rock cavities with the fluid. These differential pressures may be inappreciable or may be so high that the openings are closed by pressure before they can be filled with the fluid. The effect from openings which lie between these two extremes might result in a compressibility which is high for increasing pressure and low for decreasing pressure. Bridgman concluded that some of the reverse hysteresis he observed in his measurements on changes of length in rock with pressure might be due to this effect.

By way of summation, it would seem from an analysis of the results that a linear method which demands much more in the way of homogeneity and perfection of elastic properties than does a volume method is not as well adapted as the latter method for such heterogeneous materials as rocks, particularly at low pressures.

Secondly, low-pressure experimental results will not be reproducible or strictly applicable to treatment by the classical theory of elasticity unless the irreversible phenomena of plasticity (permanent set) and elastic afterworking be eliminated. Again, a rock specimen will not be representative of its parent rock body because the state of strain is a function not only of the external conditions prevailing at the time but also of the past strain history or conditions. A remedy for both might be obtained by giving the *sealed* specimen a preliminary seasoning at a high hydrostatic pressure, perhaps of the order of ten or twelve kilobars.

Thirdly, rock structure plays an important rôle in low-pressure compressibility but becomes less important as pressure is increased; at 12 kilobars the rock compressibility does not differ very markedly from the volume average of the mineral compressibilities. The slope, $\partial\beta/\partial p$, to 12 kilobars includes then practically the major effect of the rock structure. Compressibilities obtained by extrapolating experimentally determined slopes of crystalline rocks to much higher pressures will therefore be too low. A more representative slope, $\partial\beta/\partial \mathrm{p}$, for high-pressure extrapolation will be the average $\partial\beta/\partial \mathrm{p}$ of the component minerals (averaged by volume percentages).

Fourthly, Zisman found that low-pressure elastic moduli resulting from dynamic methods are higher than those from static methods.

An explanation of this discrepancy, namely, that there is a discrimination by the former resulting in data that in effect ignore the presence of cracks and cavities in rocks, seems reasonable. The first impulse, for example, of a compressional train of waves recorded on a seismograph will be the strongest because it will have lost the least amount of energy. Since this is taken as the travel time of the compressional wave there is introduced a kind of discrimination which is *observational* in character. Elastic moduli obtained from such data will rep-

TABLE 1.—COMPRESSIBILITY OF GRANITE IN RECIPROCAL BARS.

		Pressure in bars			
		1	700	2000	10,000
Mean, calculated from F. D. Adams and Coker's measurements (mean stress 350 bars)		3.30			
Zisman, covered					
	Quincy	8.32	2.41		
	Rockport	9.17	2.66		
Zisman, uncovered					
	Quincy	2.17	1.84		
	Rockport	1.95	1.73		
Calculated from minerals		2.03	2.01	1.98	1.77
L. H. Adams and Williamson (average of three)					
	Covered	(2.15)	(2.13)	2.08	1.79
	Uncovered	(2.23)	(2.20)	2.14	1.79
Calculated from Leet and Ewing's seismic measurements		2.28			

resent paths of high elasticity in rocks, that is, paths which include a minimum of open spaces. In order to duplicate seismic data, then, the effect of such cracks and cavities must be eliminated from static measurements. For closely bonded mineral grains such as are found among igneous rocks an extrapolation from high-pressure experimental data should agree with low-pressure seismic data. Such a comparison is made in the following table and diagram using granite as the example because the data for it are rather complete, and furthermore the salic rocks as exemplified by granite yield more typical results than do the femic rocks. They are probably also of more interest geologically in the low-pressure field of experimentation.

From the table and diagram it is seen that the best agreement with the near-surface compressibility calculated from the seismic data of

Leet and Ewing[10] is the value obtained (in parentheses) by direct extrapolation downwards of Adams and Williamson's high-pressure measurements.

The femic rocks are more unstable than the salic rocks when exposed to weathering, and this weathering by loosening the rock structure and by alteration of the original minerals can have a large effect

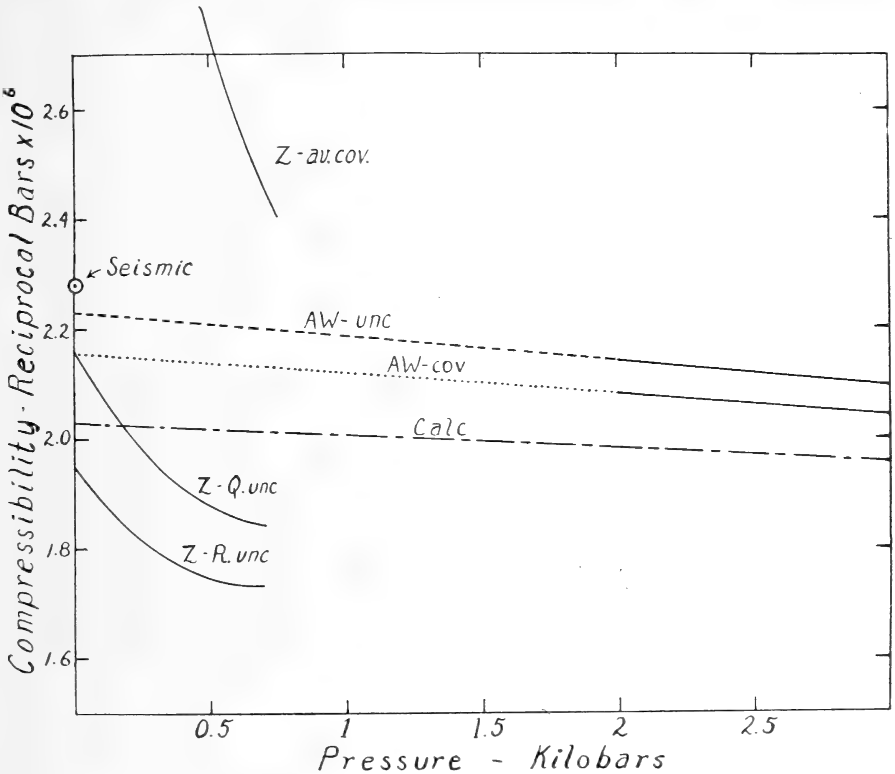

Fig. 1.—Compressibility of granite plotted as a function of pressure; compressibility β in reciprocal bars $\times 10^6$, pressure in kilobars (1 kilobar $= 10^9$ dynes cm^{-2}). *Z-av. cov* refers to average of Zisman's results on covered granites; *Seismic* refers to Leet and Ewing's seismic results on granite; *AW-unc* and *AW-cov* refer to averages of Adams and Williamson's results on uncovered and covered granites respectively, broken lines are extrapolations downwards from high-pressure results; *Z-Q. unc* and *Z-R. unc* refer to Zisman's results on uncovered Quincy and Rockport granites respectively.

on the compressibility of the rock. Measurements made on various diabases result in compressibilities which vary from 1.2 to 1.8×10^{-6} reciprocal bars at 2 kilobars, the freshest rock having the smallest compressibility. This range of values is very materially reduced at higher pressures (at 10 kilobars it is 1.1 to 1.3×10^{-6}) but indicates

[10] L. D. Leet and W. M. Ewing. Physics. **2**: 160. 1932. L. D. Leet. Physics. **4**: 375. 1933.

that for low pressures, which mean shallow depths and therefore more or less weathering of the rock, a satisfactory average compressibility cannot be obtained. The seismic compressibility of Sudbury norite, from Leet and Ewing's measurements, is 1.56×10^{-6} which corresponds with a downward extrapolation of the mean of values given above, but this is probably merely a coincidence.

Laboratory data comparable with near-surface seismic data cannot be obtained for loosely consolidated rocks such as some sandstones, shales, etc., by any kind of high-pressure extrapolation because here looseness of mineral bonding plays a large rôle.

PALEONTOLOGY.—*The pelecypod genus* Vulsella *in the Ocala limestone of Florida and its bearing on correlation.*[1] F. STEARNS MAC NEIL, U. S. Geological Survey. (Communicated by W. C. MANSFIELD.)

This paper records from the Eocene Ocala limestone of Florida a new species belonging to the pelecypod genus *Vulsella.* Though well known in other parts of the world, the genus has been nearly unknown in the Americas, in fact, the specimens here described constitute only the second reported occurrence in the western hemisphere. The first record was based on a small specimen of *Vulsella* found living off the Pacific coast of Nicaragua and now in the U. S. National Museum (U. S. Nat. Mus. Cat. No. 101935). Dall[2] made this specimen the type of a new species, *Vulsella pacifica* Dall, though there can be but little doubt that it is identical with a form now inhabiting oriental seas, and that it arrived in the eastern Pacific in comparatively recent times. Commenting on the distribution of the genus *Vulsella,* Dall reported the find as the first known occurrence of the genus in the Americas. His remark may be extended to include the entire family.

The species of *Vulsella* are extremely variable. Of the many Recent forms described as species, probably only three or four are valid. Smith[3] retains four in his revision of the genus, whereas Cox[4] after an examination of a large number of specimens from the Eocene of Somaliland believes that even some genera proposed on the basis of fossils may represent mere individual variations.

[1] Published by permission of the Director of the U. S. Geological Survey. Received April 6, 1934.

[2] DALL, W. H. U. S. Nat. Mus. Proc. **52**: no. 2183, p. 403. 1917.

[3] SMITH, E. O. Malacolog. Soc. London Proc. **9**: 306. 1910–11.

[4] COX, L. R. Roy. Soc. Edinburgh Trans., pt. 1 (no. 2). 1931.

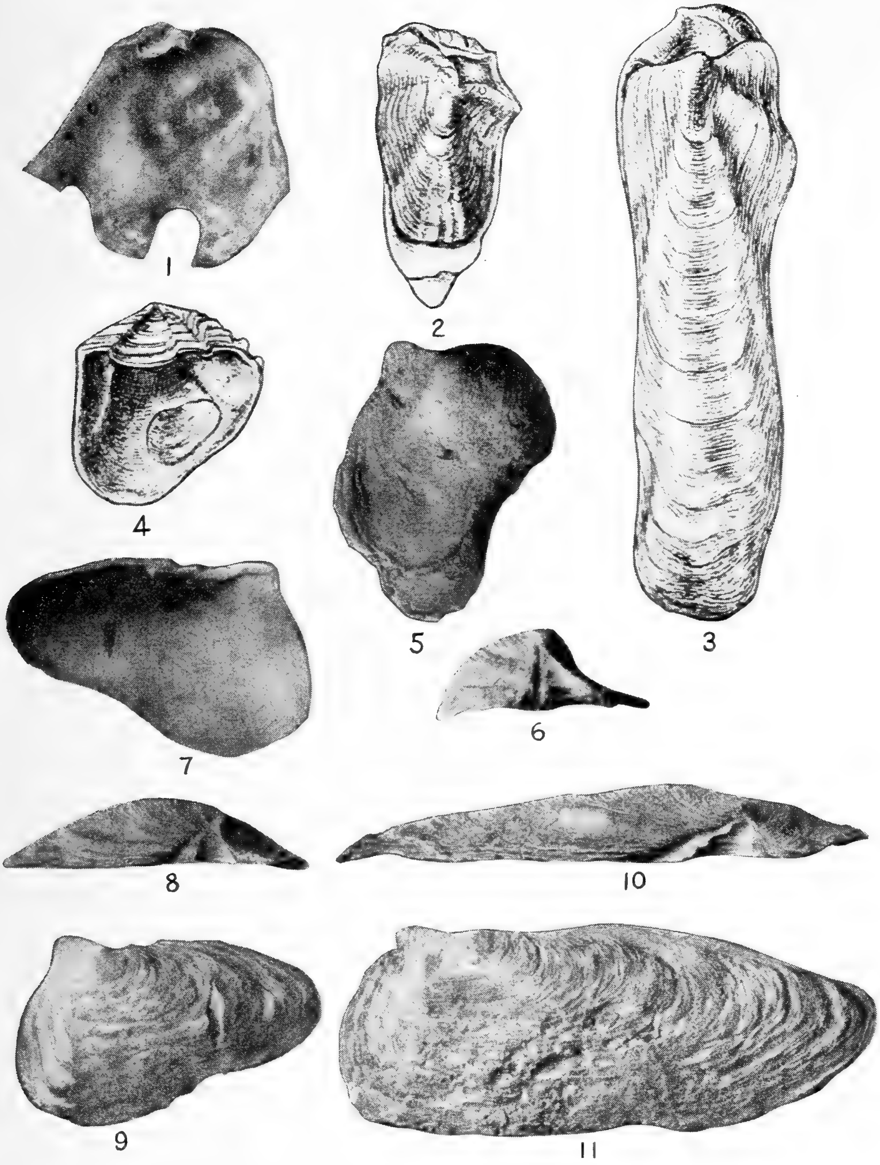

Fig. 1.—*Vulsella deperdita* Lamarck, $\times 1\frac{1}{2}$. Calcaire grossier. Ully St. George, Oise, France.

Figs. 2–4.—*Vulsella woodi* Teppner, after Wood. Bartonian. Barton, England.

Figs. 5–11.—*Vulsella ocalensis* Mac Neil, n. sp. 5–6.—Juvenile form, $\times 3$. Cotype, 2 miles northeast of Sumpterville, Sumpter County, Fla. 7–9.—Young adult, $\times 1\frac{1}{2}$. Paratype, $1\frac{1}{4}$ miles south of Newberry, Alachua County, Fla. 10–11.—Adult, $\times 1\frac{1}{2}$. Cotype, same locality as Figs. 5–6.

There is probably not sufficient material in collections in America to permit a satisfactory systematic study of the species or possible genera of the Vulsellidae. To the writer, however, the suggestion is strong that the Ocala species forms with *Vulsella deperdita* Lamarck[5] (Fig. 1), from the Calcaire grossier of France, and *Vulsella woodi* Teppner[6] (Figs. 2–4), from the Barton beds of England, a small group whose pronounced aviculid characters may warrant separation as a distinct genus.

Deshayes[7] made the following remarks on the peculiarities of *Vulsella deperdita:*

> "Elle se distingue de ses trois congénères du bassin de Paris [*V. minima, V. angusta, V. anomala*] par ses crochets obliques et même divergents, formant dans le jeune âge, un commencement de spire. Le bord de la fossette se détache sous le forme d'une crête tranchante qui suite le movement spiral du crochet et l'accompagne jusqu'au summet."

The "bord de la fossette" is, more correctly, the posterior dorsal margin of the shell.

The group of *V. deperdita* is the only group of vulsellids in which the posterior dorsal margin remains alate or sub-alate in the adult and, with the exception of the enigmatical *Naiadina herberti* Munier-Chalmas, the only group showing a tendency to anterior inflation or elongation. Furthermore, Recent shells of the genus *Vulsella* consist of vertical prismatic crystals on a thin internal nacreous layer, whereas the new species from Florida has an external layer of very oblique fibro-lamellar elements. The prisms of *V. deperdita* are also oblique to the surface.

The writer believes that the next revision of the Vulsellidae, which should be made from Old World collections, should make use of the differences here pointed out.

Curiously enough, confusion has run riot in the orientation of the shells of the Vulsellidae. We are certainly at a loss to know why Bernard[8] disregarded his own principles of morphology and incorrectly designated the anterior and posterior ends of his fine sketch of an extremely young shell of *Vulsella rugosa* Lamarck. Stoliczka[9] ran aground on the assumption of a byssus. Vaillant[10] readily saw the true axial relations upon the dissection of living specimens of *V.*

[5] Deshayes, G. P. *Animaux sans vertèbres dans le Bassin de Paris.* Texte II, p. 51. 1864.

[6] Teppner, W. Centralbl. Mineralogie, Geologie, Paläontologie, **16**: 501. 1914.

[7] Deshayes, G. P. Op. cit. p. 51.

[8] Bernard, F. Annales sci. nat., Zoologie. 8th ser., **8**: 124, *pl. 8, figs. 6, 7.* 1898.

[9] Stoliczka, F. Palaeontologia Indica, p. 396. 1871.

[10] Vaillant, L. Annales sci. nat., Zoologie, 5th ser., **9**: 284. 1868.

rugosa Lamarck, and Fischer follows him in his *Manuel de Conchyliologie*. Munier-Chalmas[11] and Douville[12] seem to be in correct accord over Recent forms and fossils most nearly related to them, but the anterior marginal inflation of *Vulsella deperdita* Lamarck they confused with the posterior marginal notch of certain Recent and fossil forms.

The new species offered in this paper may be described as follows:

Vulsella ocalensis Mac Neil, n.sp.

Figures 5–11

Shell sub-ostreiform, anteriorly inflated and elongate, thin except at umbo, where it is thickened or camerate; exterior shell layer composed of oblique fibro-lamellar elements, inner layer laminar and compact, probably nacreous, but possibly laminar calcitic; adult sculpture roughly concentric; umbo sub-spiral and opisthogyrate; posterior dorsal margin sharply alate and following the rotation of the beak; ligament area depressed, acute and posteriorly directed in extremely young shell but becoming wider and more anterior in adult; ligament area containing a single deep ligament pit, at first directed posteriorly along the hinge line but swinging anteriorly with the widening of the ligament area; muscle scar just anterior to the beak and close to the ventral margin; anterior ventral corner of ligament area forming a toothlike projection on the otherwise edentulous hinge line.

All of the types are right valves.

Dimensions of larger cotype: length 48 milimeters, height 19 millimeters, convexity 7 millimeters.

Type localities: Cotypes (U. S. Nat. Mus. Cat. No. 373052), Sumpter Rock Co. quarry, about 2 miles northeast of Sumpterville, Sumpter County, Fla. (U. S. G. S. Sta. No. 12751); collectors: W. C. Mansfield and G. M. Ponton, 1932. Paratype (U. S. Nat. Mus. Cat. No. 373053), Cummer Lumber Co., $1\frac{1}{4}$ miles south of Newberry, Alachua County, Fla. (U. S. G. S. Sta. No. 6812); collector: C. W. Cooke, 1913.

The point of greatest interest in the new Ocala species is the fact that it provides what is probably as good a criterion as any now known for trans-Atlantic correlation. *Vulsella woodi* from the Bartonian and *Vulsella ocalensis* from the Ocala limestone, both rare but intimately related species with a limited geologic range, are not clearly related to any other species of *Vulsella* except their probable prototype, *Vulsella deperdita* from the Calcaire grossier.

A very striking series is seen as we pass from the ventrally elongate, subalate *Vulsella deperdita* through the intermediate *Vulsella woodi* to the anteriorly elongate, conspicuously eared *Vulsella ocalensis*.

[11] MUNIER-CHALMAS, M. Linnean Soc. Normandie Bull. **8**: 100. 1863.
[12] DOUVILLÉ, H. *Étude sur les Vulsellidés*. Annal paléontologie. **2**: 1907.

BOTANY.—*New Asteraceae from Guatemala collected by A. F. Skutch.*[1]
S. F. Blake, Bureau of Plant Industry.

This paper contains descriptions of the new Asteraceae (except the tribe Eupatorieae and the genus *Senecio*) contained in a collection amounting to about 650 numbers made by the ornithologist, Dr. Alexander F. Skutch, in the mountains north of Tecpam (Tecpán), Department of Chimaltenango, Guatemala, in 1933. From the southern base of the mountains, at about 2135 meters elevation (7000 ft.), to about 2745 meters (9000 ft.) the woods are made up mainly of oak, alder, and pine; above 9000 ft. the virgin forests are nearly pure cypress (*Cupressus benthami* Endl.), with a slight admixture of pine and dicotyledonous trees, but no oaks. Lumbering operations above the 9000 ft. level have been followed in some cases by the growth of secondary forest composed of mixed dicotyledonous trees; other areas have grown up again to nearly pure stands of cypress. Below the 9000 ft. level the sporadic but extensive and wasteful native cultivation has left much cleared land and bushy pastures; the most conspicuously abundant composite in such areas throughout the region, but particularly below the 9000 ft. level, is *Baccharis vaccinioides* H. B. K., which sometimes reaches a height of about 10 meters. The two principal localities at which collections were made by Dr. Skutch, Chichavac and Santa Elena, are haciendas in the mountains north of Tecpam, the former three miles from the town and at about 2440–2745 meters altitude, the latter six miles north and at about 2745–3050 meters elevation.

Archibaccharis prorepens Blake, sp. nov.

Herba erecta ca. 5 dm. alta, rhizomate repente; caulis tenuis striato-angulatus pilosulus pilis crispatis multilocularibus; folia oblongo-elliptica v. lanceolata ca. 4 cm. longa acuta basi cuneata argute serrata triplinervia breviter petiolata utrinque in nervis et venis sparse crispo-pilosula; capitula staminea pauca cymosa mediocria ca. 5 mm. alta.

Rhizome slender, about 1.5 mm. thick, 30 cm. long and more; stem about 54 cm. high, 1.5 mm. thick, straight or essentially so, simple below the inflorescence, green, sharply several-striate, not densely pilosulous, especially above, with brownish hairs; leaves alternate; internodes 0.6–2 cm. long; petioles about 2 mm. long, pubescent like the stem; blades 2.5–4 cm. long, 9–12 mm. wide, merely acute, sharply serrate above the entire or subentire lower third or quarter (teeth slender, acuminate, antrorse, 0.5–1.5 mm. long), above deep green, sparsely brownish-pilosulous on the chief nerves and veins (these impressed), beneath paler green, sparsely brown-pilosulous on nerves, veins, and veinlets, definitely but not strongly triplinerved and prominulous-reticulate beneath; some of the upper leaves with short leafy

[1] Received June 25, 1934.

branchlets in their axils; heads 8, cymosely arranged, the pedicels slender, angulate, finely crisped-pilosulous, 8–15 mm. long, naked or with a minute bract; heads subcampanulate, 5–6 mm. high and thick, 15-flowered; involucre about 3-seriate, graduate, 4.5–5 mm. high, the phyllaries linear or linear-oblong, acute or subacuminate, loosely and not densely rather long-ciliate especially toward apex, with green 1-ribbed center and narrower subscarious whitish margins, often purple toward apex; flowers in the head all staminate; ovaries abortive; corollas whitish, about 4.8 mm. long (tube sparsely puberulous with clavellate hairs, 2–2.2 mm. long, throat campanulate, nearly glabrous, 0.8–1 mm. long, teeth triangular, sparsely puberulous, spreading, 1.5–1.8 mm. long); style branches slender, subulate-tipped, hispidulous, 1 mm. long.

GUATEMALA: Clearing in the forest, Santa Elena, Dept. Chimaltenango, alt. 2400–2700 m., 22 Jan. 1933, *A. F. Skutch* 190 (type no. 1,494,847, U. S. Nat. Herb.).

Archibaccharis prorepens is related to *A. simplex* Blake, of Hidalgo, in which the stem is sparsely incurved-hispidulous and the leaves larger (3.5–7 cm. long, 1.3–2.2 cm. wide), feather-veined, and cuneate-oblanceolate to elliptic-obovate.

Archibaccharis hirtella var. **taeniotricha** Blake, var. nov.

Rami eglandulosi dense et sordide patenti-pilosi pilis articulatis.

OAXACA: Climbing over shrubs to 15 ft. in oak woods, Sierra de Clavellinas, alt. 2745 m., 18 Oct. 1894, *Pringle* 4988; Sierra de Clavellinas, alt. 2745 m., 16–19 Oct. 1894, *C. L. Smith* 259. GUATEMALA: Woody vine, scrambling over other vegetation in the cypress forest, sometimes epiphytic and rooted on moss-covered trunks, Santa Elena, Dept. Chimaltenango, alt. 2400–2700 m., 24 Feb. 1933, *A.F. Skutch* 276 (type no. 1,494,938, U. S. Nat. Herb.) (pistillate); woody vine, cypress woods, Santa Elena, alt. about 2900 m., 24 Dec. 1933, *Skutch* 769 (staminate).

Dr. Skutch's two collections of this plant differ so much in pubescence from most of the material of *A. hirtella* (DC.) Heering available that I have been led to make a reexamination of all the specimens of this species in the U. S. National Herbarium. It proves to be divisible into three forms, two of which are very distinct, the third less so. In 1925 I examined in the Prodromus Herbarium the type of *Baccharis hirtella* DC., collected by Haenke at some unknown locality in Mexico on his journeys between Acapulco and the City of Mexico, and noted that it was very closely matched by *Pringle* 11483, from mountains above Eslaba in the Federal District. In this form the branches and inflorescences are densely puberulous with short spreading hairs, nearly all of which are gland-tipped; longer eglandular hairs are wanting or very few. The midrib of the leaves beneath is similarly glandular-pubescent or sometimes pilose with eglandular hairs. The following specimens in the U. S. National Herbarium are referable to this typical form:

STATE OF MEXICO: *Bourgeau* 955 in part; *Purpus* 18, 1499. FEDERAL DISTRICT: *Pringle* 11483. MORELOS: *Juzepczuk* 820. GUERRERO: *E. W. Nelson* 2237, 2238. OAXACA: *Nelson* 2336 (by error listed as 2236 in my paper

Fig. 1.—*Adenocaulon lyratum* Blake.—*a*, plant, $\times\frac{1}{2}$; *b*, flowering head, $\times 3$; *c*, submature achene, $\times 2\frac{1}{2}$; *d*, pistillate flower, $\times 4$; *e*, style of pistillate flower, $\times 15$; *f*, hermaphrodite flower, $\times 6$; *g*, style of hermaphrodite flower, $\times 10$; *h*, two stamens, $\times 15$.

on Hemibaccharis in 1924). MEXICO without definite locality: *Ehrenberg* 1408.

The other extreme form of the species, with the branches and inflorescences, as well as the midrib of the leaves beneath, densely spreading-pilose with many-celled brownish hairs and essentially eglandular, has been described above. The third form, less distinct than the two others, is

Archibaccharis hirtella var. **intermedia** Blake, var. nov.

Rami eglandulosi puberuli vel breviter pilosuli pilis articulatis antrorse curvatis v. incurvis interdum subpatentibus.

TEPIC: Without definite locality, Jan.–Feb. 1892, *Palmer* 1846. VERACRUZ: Shaded banks near Orizaba, alt. 1280 m., 25 Jan. 1895, *Pringle* 6108 (type no. 252873, U. S. Nat. Herb.). MORELOS: Mountain canyons above Cuernavaca, alt. 1980 m., 11 Nov. 1902, *Pringle* 9853. OAXACA: Valley of Oaxaca, alt. 1675–2285 m., 20 Sept. 1894, *Nelson* 1471.

Adenocaulon lyratum Blake, sp. nov.

Caulescens parce erecto-ramosum; caulis anguste alatus eglandulosus; folia lyrato-pinnatifida; achenia cuneato-obovoidea compressa apice late rotundata; antherae apice vix appendiculatae.

Erect perennial herb, about 75 cm. high, the very short rootstock bearing a cluster of fleshy fibrous roots; subterranean portion of stem about 5 cm. long, bearing a few small scales; stem slender, sparsely erect-branched, thinly arachnoid-tomentose, glabrescent or glabrate, narrowly winged throughout except in branches of inflorescence by the decurrent leaf-bases (wings arachnoid-tomentose on one side, 2 mm. wide or less); principal leaves 6–8, crowded near base of stem, lyrate-pinnatifid, obovate in outline, 20–27 cm. long, 6–10.5 cm. wide, above thinly arachnoid, quickly green and glabrate except for short subglandular hairs along the veins, beneath thinly and persistently canescent-arachnoid-tomentose, feather-veined, the terminal lobe pentagonal-deltoid, slightly cordate, acute or obtusish, shallowly repand and minutely mucronulate on margin, the lateral lobes 2–4 pairs, decreasing in size toward base of leaf, broadly oblong to obovate or suborbicular, acute to very obtuse, spreading or retrorse, the broadly margined petioliform base of leaf entire, 3–9 cm. long; leaves above base of stem few (about 3–4), the lower similar to the basal but smaller and with shorter more broadly margined petioliform base, the upper with only 1–2 pairs of lobes; inflorescence branches thinly arachnoid, glabrescent, eglandular, with minute subulate bracts, the heads solitary or paired in the axils, their peduncles erect, at first thickly arachnoid-tomentose, becoming 4 cm. long; heads 10–16-flowered, in flower 2–3 mm. thick; phyllaries subuniseriate, 6–8, subequal, ovate, acute, 1.5–2 mm. long, 0.8–1.2 mm. wide, thin-herbaceous, thinly arachnoid outside, reflexed in age; pistillate flowers 5–8, their corollas white, 0.7–1 mm. long (tube 0.2–0.3 mm. long, teeth 4–5, recurved-spreading, ovate-oblong, acutish, 0.5–0.7 mm. long); hermaphrodite flowers 5–8, the ovary abortive, glabrous, 1.2 mm. long, the corolla white, about 2.2 mm. long (tube cylindric, 0.8 mm., throat funnelform, 0.3–0.4 mm., teeth 5, oblong-ovate acutish, papillose outside at the slightly thickened apex, 0.8–1 mm. long; achenes (not mature) cuneate-obovoid, compressed, green, about 3-nerved on each side, stipitate-glandular, 5.5 mm. long, 3 mm. wide.

GUATEMALA: In open oak woods, Chichavac, Dept. Chimaltenango, alt. 2530 m. (8300 ft.), 20 Sept. 1933, *A. F. Skutch* 622 (type no. 1,587,623, U. S. Nat. Herb.).

This plant is a most distinct and unexpected addition to one of the most distinctive genera of the family Asteraceae. Only five[2] nominal species of the genus have hitherto been recognized from the western United States and Canada, eastern Asia, and southwestern South America. In the best known species, *Adenocaulon bicolor* Hook., ranging from British Columbia to south-central California, eastward to Montana and sparingly to Michigan, the stem is stipitate-glandular, especially above, and the leaf blades are deltoid or ovate-deltoid, from subentire to shallowly sinuate-toothed or -lobed, usually hastate at base, and borne on a narrowly winged petiole usually much longer than the blade. The leaves are chiefly basal or subbasal, although sometimes extending half way up the stem. Two species have been described from eastern Asia, *A. himalaicum* Edgew. of the Himalayan region, at about 1830–3660 meters elevation (6–12000 ft.), and *A. adhaerescens* Maxim. of Japan. The two are generally considered identical, and are so closely allied to *A. bicolor* that they have been combined with it as a variety (var. *adhaerescens* (Maxim.) Makino) or even united outright, as by Hooker in the *Flora of British India*. The material at hand, although insufficient to settle the status of the Asiatic forms, indicates that the plant of China and Japan is specifically distinct from *A. bicolor*. Two species have been described from southern Chile and the Magellan region, *A. chilense* Poepp.[3] and *A. lechleri* Sch. Bip. The material available is again too slight to enable me to form an opinion as to the distinctness of the supposed species. Reiche, who combines them under the name *A. chilense*, assigns the species a range "en los montes claros de *Nothofagus pumilio*" from the cordilleras of Nahuelbuta and Chillan to the Strait of Magellan. In this plant the stem and inflorescence are purple-glandular, and the leaves oblong or elliptic-oblong, faintly crenate-denticulate, cuneate-rounded to subcordate at base, and narrowly decurrent on the upper part of the petiole, which is about equal to or much shorter than the blade. The Guatemalan *A. lyratum*, constituting the third distinct group in this obviously relict genus, is readily distinguished by its lyrate-pinnatifid leaves, its leafy, winged, eglandular stem, and its comparatively broad, cuneate-obovoid achenes.

The floral details of the species of *Adenocaulon* have not been sufficiently noticed. Bentham and Hooker, in the *Genera Plantarum*, described the corollas as all regular and tubular, and the anthers as entire or barely minutely 2-dentate at base. They placed the genus in the Helianthoideae-Millerieae.

[2] Not coun ting *Adenocaulon integrifolium* Nutt., universally regarded as identical with *A. bicolor*.

[3] This species is universally attributed to Lessing, but was published by him as of Poeppig. An interesting commentary on the un-Composite-like appearance of the plants of this genus is furnished by the synonym *Boerhaavia nudicaulis* Phil., cited by Reiche under *A. chilense*.

Gray,[4] in his notes on Bentham's work, called attention to the fact that the anthers are strongly sagittate at base, and referred the genus to the Inuleae as a separate subtribe, the Adenocauloneae. Some years later[5] he stated, after examining all the species, that "the basal auricles of the sagittate anthers are manifestly produced into a slender acumination or small tail, the adjacent ones connate," and suggested that *Carpesium* might be associated with *Adenocaulon* in this subtribe, the name of which he emended to Adenocauleae. In the *Synoptical Flora*[6] he described the anthers as "minutely but evidently caudate, connate," and noted that the corollas of the pistillate flowers are bilabiate in the Chilean species, with the outer lip 3-lobed; those of the Californian species he regarded as regularly 4-lobed.

Adenocaulon chilense is, in its floral details, the most highly developed species of the genus. The corollas of the pistillate flowers are, as described by Gray, bilabiate. The outer lip is oval, at first erectish and somewhat boatshaped, later recurving, and is merely 3-dentate or 3-denticulate; the inner is sometimes entire and apparently made up of a single linear lobe, sometimes 2-dentate, sometimes 2-parted to base. The anthers have ovate or triangular-ovate terminal appendages of normal size and at base are deeply sagittate and provided with linear papillose tails, connate as in the other species, the adjoining ones often decidedly unequal. The style branches in the pistillate flower are rather smaller than elsewhere in the genus, and ovate or quadrate, obtuse; the style in the hermaphrodite flowers is slightly clavate and papillose above, and is barely notched or sometimes bifid.

In *Adenocaulon bicolor*, of western North America, the corollas of the pistillate flowers are usually 4-lobed, sometimes 3-lobed, and are either essentially regular, or slightly irregular with somewhat smaller inner lobe. The anthers have conspicuous triangular-ovate or almost subulate terminal appendages and at base are provided with usually inconspicuous tails, these short- or elongate-triangular. The style branches in the pistillate flower are relatively large, quadrate or even subflabellate, and are subtruncate or broadly rounded with somewhat wavy margin; the style in the hermaphrodite flowers is cylindric or slightly clavate, papillose above, and entire.

The material at hand from eastern Asia consists of 10 sheets, all from Japan and China, no material from the Himalayas, the type region of *A. himalaicum* Edgew., being available. In general appearance this plant, *A. adhaerescens* Maxim., is similar to *A. bicolor* of western North America, but the heads are larger and more numerously flowered and the leaves, at least in the Chinese material, are reniform or reniform-orbicular rather than deltoid. Most of the Japanese material, however, has the leaves shaped more as in the North American plant, but with conspicuously winged petioles which are often considerably dilated at the base. Better and more mature material (all these specimens except one being without fruit) might make it

[4] Proc. Amer. Acad. **8**: 653. 1873.
[5] Proc. Amer. Acad. **17**: 214. 1882.
[6] Syn. Fl. **1**^{2}: 59. 1884.

possible to distinguish more than one Asiatic form. At any rate, as a group they differ sufficiently in floral details to indicate that they are not specifically identical with the North American plant. The pistillate corollas are usually 5-lobed (rarely 4-lobed) and are distinctly irregular, the 2 inner lobes being shorter than the 3 outer and sometimes united to well above the middle. The style branches in the pistillate flower are smaller than in *A. bicolor*, and more or less quadrate; the style in the hermaphrodite flowers is not distinguishable from that of *A. bicolor*. The principal difference, already indicated by Edgeworth for his *A. himalaicum*, is that the terminal appendages of the anthers are greatly reduced, varying from a short deltoid tip to a mere convexity or a blunt mucro. The basal appendages, also, are less developed than in *A. bicolor*.

In *Adenocaulon lyratum* the pistillate corollas are regularly 4-5-lobed, with spreading lobes. The style branches in the pistillate flowers are broadly oblong and truncate; the style in the hermaphrodite flowers is slightly clavate and minutely indented at the papillose apex. The anthers have short triangular basal tails and are provided at apex with the minutest blunt mucro or are essentially without appendage. Even before the corolla opens, the anthers are already dehiscent and connate only in their lower half.

The corollas of the pistillate flowers in this genus frequently bear abortive anthers.

Calea skutchii Blake, sp. nov.

Frutex v. arbor parva; rami et ramuli dense et sordide sublanatopilosi; folia ovata petiolata serrata acuminata basi cuneata submembranacea triplinervia ca. 1.2 dm. longa supra scaberula subtus in venis et venulis omnibus pilosula in pagina glanduloso-adspersa; capitula parva radiata aurea cymoso-paniculata; involucri ca. 4-seriati ca. 6 mm. alti phyllaria exteriora oblongo-lanceolata interiora oblonga v. cuneato-obovata obtusa apice aureoscariosa pilosula et plusminusve ciliolata; achenia anguste cuneata hirsutula pappo duplo longiora; pappus eum Viguierae simulans, e aristis 2 subpaleaceis et squamellis ca. 6 subduplo brevioribus sistens.

Shrub or small tree, reaching 7.5 m. in height; branches stoutish, terete, striatulate, about 6 mm. thick, densely pilose with brownish many-celled somewhat matted hairs; internodes 3–8 cm. long; leaves opposite; petioles 1.5–3 cm. long, pubescent like the stem; blades of the larger leaves 10–17.5 cm. long, 4.5–6.5 cm. wide, acuminate and somewhat falcate, usually long-cuneate at base, serrate above the entire base (teeth about 15–25 pairs, 2–5 mm. apart, depressed-triangular, mucronulate, the mucro callous, about 0.3 mm. long), tripli-nerved 1–3.5 cm. above the base or sometimes 5-plinerved, somewhat bullate above, prominulous-reticulate beneath, above scabrid with short slightly tuberculate-based antrorse-curved hairs, beneath slightly paler, densely pilosulous on all the veins and veinlets with loosely spreading whitish hairs and along costa spreading-pilose; heads about 1.4 cm. wide, very numerous, forming a ternately divided convex or flattish panicle 18–28 cm. wide, about equaled by the leaves; pedicels slender, densely sordid-pilosulous, mostly 4–10 mm. long; disk slender-campanulate, 9–11 mm. high, 4.5–7 mm. thick (when moistened); involucre not strongly

graduated, the few outermost phyllaries oblong or oblong-ovate or -lanceolate, about 2.5–3.5 mm. long, about 0.7 mm. wide, obtuse or acutish, with subindurate body and short somewhat loose greenish apex, the others narrowly oblong to oblong- or wedge-obovate, obtuse or apiculate, about 2 mm. wide, sometimes purple-dotted or -lineolate above, with subindurate more or less vittate body, narrow yellow subscarious margin, and broad scarious rather loose yellow tip; receptacle convex; rays 8, pistillate, golden yellow, the tube 2 mm. long, stipitate-glandular, the lamina oval, 2–3-denticulate, 6–7-nerved, 5 mm. long, 3 mm. wide; disk flowers about 28–32, their corollas golden yellow, 5 mm. long (tube stipitate-glandular, 1.7 mm., throat slender-campanulate, finely stipitate-glandular, 2.5 mm., teeth ovate, slightly stipitate-glandular, 0.8 mm. long); pales narrow, about 7 mm. long, 1-nerved, pilosulous along keel especially above, puberulous toward apex, the somewhat ampliate, obtuse or apiculate, scarious, golden-yellow or sometimes brownish tip slightly spreading; achenes (immature) narrowly cuneate, compressed-quadrangular, 3.5 mm. long, 0.8 mm. wide, blackish brown, 1-ribbed and usually 2–3-nerved on each side, hirsutulous on the angles and toward apex; pappus awns 2, lanceolate, acuminate, hispidulous-ciliolate, about 1.5 mm. long; squamellae on each side about 2–4, linear to oblong, acute or lacerate, 0.5–0.8 mm. long, one sometimes joined to the awns on each side at base; style branches with short triangular finely hispidulous appendages.

GUATEMALA: Hardwood forest, Chichavac, Dept. Chimaltenango, alt. 2400–2700 m., 27 Feb. 1933, *A. F. Skutch* 294; bushy second growth on mountain side by the "Camino real" above Tecpam, Dept. Chimaltenango, alt. about 2745 m., 4 Dec. 1933, *Skutch* 729 (type no. 1,587,727, U. S. Nat. Herb.).

Although the pappus of this plant is so similar to that of *Viguiera* as to be practically indistinguishable, the fertile rays and scarious-tipped phyllaries show that it is really a *Calea* of the subgenus *Tetrachyron*, deviating somewhat in pappus character from the generally accepted definition of that group. It is quite distinct from any of the half dozen members of that group already described.

Alepidocline Blake, gen. nov.

Herba annua ramosa pubescens et parum glandulosa, foliis oppositis ovatis petiolatis serratis triplinerviis membranaceis, capitulis heterogamis radiatis mediocribus cymosis, radiis parvis albis denique roseis v. purpureis, disco aureo. Involucri ovoidei v. hemispherici gradati ca. 5–6-seriati phyllaria elliptico-oblonga v. ovalia v. intima lanceolato-oblonga viridescentia subsicca vittata obtusa v. intima acuta anguste subscarioso-marginata intima apice purpurascentia. Receptaculum convexum hirsutulum nudum vel interdum prope marginem paleis paucissimis linearibus integris onustum. Radii 1-seriati feminei fertiles, tubo elongato tenui, lamina parva patente 3-dentata. Flores disci numerosi hermaphroditi fertiles, corollis tubulosis, tubo limbo longiore, faucibus campanulatis, dentibus 5 brevibus. Stamina 5, antheris basi obtuse sagittatis, apice appendice oblongo-ovata obtusa munitis. Styli rami lineares ad apicem minute hispiduli, appendice deltoidea obtusa papillosa praediti. Achenia obovoidea obcompressa plano-convexa parva glabra nigra lucida, apice annulo brevissimo subintrorso donata. Pappus caducus e aristis ca. 8–10 1-seriatis seti-

Fig. 2.—*Alepidocline annua* Blake.—*a*, plant, $\times\frac{1}{2}$; *b*, head, $\times 3\frac{1}{2}$; *c*, receptacle, $\times 5$; *d*, ray flower, $\times 5$; *e*, disk corolla, $\times 8$; *f*, two stamens, $\times 15$; *g*, style branches of disk flower, $\times 15$; *h*, disk achene, ventral view, $\times 8$; *i*, same, lateral view; *j*, same in cross section; *k*, apex of achene, enlarged; *l*, pappus awn, $\times 13$.

formibus parum inaequalibus hispidulis sistens.—Species typica *Alepidocline annua*, sp. nov.

Alepidocline annua Blake, sp. nov.

Character ut supra donatus.

Slender erect annual, 6–8 dm. high, with opposite erectish or spreading-ascending branches; stem 2.5–5 mm. thick, terete, striatulate especially above, purplish, sparsely spreading-pilose especially just below the nodes with several-celled, acuminate, white, not tuberculate-based hairs and in the region of the inflorescence with some shorter gland-tipped hairs; internodes 6.5–16 cm. long, petioles slender, flattened, pilose on margin and back, 5–30 mm. long, connate in a line at base; blades 4.5–7.5 cm. long, 2.5–4.5 cm. wide, acuminate and often somewhat falcate, cuneate at base, serrate above the entire or subentire cuneate base (teeth about 9–18 pairs, 2–4 mm. apart, usually depressed-deltoid, with short obtuse callous usually purplish mucros), triplinerved a little above the base and lightly prominulous-reticulate beneath, above rather light green, sparsely and uniformly pilose with few-celled spreading white hairs (the basal cell short, somewhat swollen, and subglandular) and on the veins sparsely pilose with shorter many-celled hairs, beneath scarcely paler green, similarly but somewhat more densely pubescent; heads about 5–8 mm. wide, in small cymes of 2–4 at tips of stem and branches, together forming a loose leafy panicle, the pedicels naked, 1.5–4 cm. long, spreading-pilosulous and with sparse shorter gland-tipped hairs; disk 6–7 mm. high, about 5–6 mm. thick; involucre 5–6.5 mm. high, in the dried state hemispheric, 6–10 mm. thick, when moistened bluntly ovoid (in young flower, then 5 mm. thick) to campanulate-hemispheric (when submature, then 6 mm. thick), the outermost phyllaries elliptic or oblong, about 2.5 mm. long, 1 mm. wide, obtuse, about 3-nerved, slightly ciliolate, the middle ones oval, 2.5–3 mm. wide, 6–7-nerved, the inner oblong-lanceolate, acute or acuminate, obscurely ciliolate, the inner and often the middle with purplish tips, all appressed; rays 10–17, the tube spreading-pilosulous, 3.2–5 mm. long, the lamina quadrate-oblong, white turning pink or purplish with age, 1.5 mm. long, 1 mm. wide, 3-dentate, 5–7-nerved; disk flowers numerous, their corollas yellow, 3–3.5 mm. long (tube spreading-pilosulous, 2–2.2 mm. long, throat slender-campanulate, essentially glabrous, 0.7–1 mm. long, teeth ovate, hispidulous, 0.3–0.4 mm. long); achenes obovoid, 1.5 mm. long, 0.8 mm. wide, black, shining, glabrous, finely and rather obscurely several-striatulate, plano-convex or sublenticular, the outer face rounded, the inner flattish or somewhat rounded, sometimes sulcate or bluntly 1–2-ribbed; pappus awns whitish, 1.5–1.8 mm. long.

GUATEMALA: Weed in cornfield, Chichavac, Dept. Chimaltenango, alt. 2430 m. (8300 ft.), 2 Dec. 1933, *A. F. Skutch* 722 (type no. 1,587,766, U. S. Nat. Herb.).

Although only a cornfield weed, this plant evidently represents a new genus allied to *Schistocarpha*, but differing in its essentially naked receptacle and in its obcompressed achene with rounded summit and slightly introrse apical annulus, much narrower than the achene and bearing a pappus of fewer, slightly stouter, setiform awns. In *Schistocarpha* the receptacle is paleaceous throughout, with a usually trifid pale at the base of each flower, and the achenes are slenderly obovoid-oblong, subterete or slightly 3–5-

angulate, truncate at apex, and bearing a short slightly expanded collar terminating in a disk composed of the united bases of the numerous pappus bristles, from which the fragile bristles themselves are readily deciduous. In its general appearance, *Alepidocline* is suggestive of the tribe Heliantheae. The generic name is derived from α, privative, λεπίς, a scale, and κλίνη, a bed.

Cirsium guatemalense Blake, sp. nov.

Bienne 1.5 m. altum, radice tenui elongato; caulis arachnoideo-lanatus supra pauci-ramosus; folia oblonga v. lanceolato-oblonga sessilia breviter decurrentia acuminata usque ad vel ultra medium pinnatifida supra tenuiter arachnoidea mox glabrescentia v. glabrata non setosa subtus canescenti-tomentosa submembranacea, lobis ca. 11-jugis oblongis sinuato-dentatis v. sinuato-lobatis saepe subbifidis modice spinosa, spinis tenuibus albidis 3–5 mm. longis; capitula ca. 8–10 majuscula ca. 3–4 cm. alta 4–5 cm. crassa ut videtur nutantia saepius solitaria in ramis elongatis foliosis; involucri 2.7–3.5 cm. alti valde et regulariter gradati ca. 8-seriati basi bracteis paucis parvis spinoso-pinnatis donati phyllaria erecta v. appressa anguste triangularia integra sensim acuminata margine infra spinam dense et pulchre canescenti-arachnoideo-tomentosa nigrescenti-viridia anguste et pallide subscarioso-marginata, omnia (intimis innocuis exceptis) spina erecta subvalida albida 3–7 mm. longa donata; corollae albidae, limbo tubo paullo breviore paullum infra medium 5-fido.

Evidently biennial, the rather slender scarcely branched root 14 cm. long and more; stem rather stout, 8–14 mm. thick, striate, erect, hollow, rather thinly brownish-arachnoid-lanate; internodes 2–6 cm. long; principal leaf blades 15–30 cm. long, 5–12 cm. wide, decurrent for 0.5–3 cm. (the wings spiny-lobed), soon bright green above and nearly or quite glabrous except for some sordid pilosity along costa and chief lateral veins, beneath densely canescent-tomentose and along the costa brownish-lanate, the terminal lobe slender, acuminate, 2.5–4.5 cm. long, tipped with a spine about 3 mm. long, the lateral lobes about 2–4 cm. long and about 1.2–3 cm. wide, their teeth and tip bearing rather weak whitish spines 2–4 (–8) mm. long; heads solitary (rarely in 3's) on erectish leafy branches or peduncles 18–30 cm. long, their leaves similar to those of main stem but much smaller (4.5–8 cm. long) and with only about 5–7 pairs of teeth or short lobes, their spines up to 10 mm. long; involucre (in dried state) hemispheric, umbilicate at base, the phyllaries 1.2–2.5 mm. wide below, 1-ribbed at apex, not glandular, the inner purplish toward base of spine, the inmost with very narrow erectish entire purplish subscarious tip; corollas 2.1–2.7 cm. long (tube 12–14 mm., throat distinct, 4–6 mm., teeth linear, acute, slightly thickened subapically, 5–7 mm. long); achenes oblong, blackish with whitish apex, glabrous, shining, 4.5 mm. long; pappus whitish, 2 cm. long, the awns all plumose, about 10 of the inner slightly thickened at apex; anthers light purple, with narrowly triangular, slenderly acuminate tips; node of style obscure.

GUATEMALA: Edge of oak woods, Chichavac, Dept. Chimaltenango, alt. 2530 m. (8300 ft.), 10 Nov. 1933, *A. F. Skutch* 660 (type no. 1,587,661–3, one plant mounted on three sheets).

Cirsium guatemalense finds its nearest ally, apparently, in *C. radians* Benth., also Guatemalan. In that species, however, according to Petrak's description,[7] the phyllaries are more or less dimorphous, the outer longer

[7] Beih. Bot. Centralbl. **27**: Abt. 2: 240. 1910.

and subrecurved, with a long spreading spine, the inner erect and not spinose. In *C. guatemalense* the phyllaries (except the inmost) are all similar, erect, and strongly graduated in length from the short outer to the long inner.

BOTANY.—*The American species of* Elytraria.[1] E. C. LEONARD, U. S. National Museum. (Communicated by E. P. KILLIP.)

Elytraria, a genus of Acanthaceae, subfamily Nelsonioideae, was described[2] by Michaux in 1803. He published at this time a single species, *E. virgata*, citing as a synonym *Tubiflora carolinensis* Gmel.[3] Although antedating *Elytraria, Tubiflora* is rejected by the International Rules. Since Michaux's publication about 30 species have been described by various authors, though most of these have been reduced to synonymy.

The name *Elytraria* is derived from the Greek ϵλυτρον (*elytron*, sheath), in reference to the firm coriaceous bracts which sheathe the scapes and subtend the flowers. When herbaceous and having a rosette of basal leaves, fibrous roots, and simple scapes tipped by cylindric spikes, these plants superficially resemble the common plantain (*Plantago*). The flowers are white or blue, and inconspicuous. In *E. tuberosa*, here described as new, the roots are thick-fusiform, resembling those of *Ruellia tuberosa*. In all other species of the genus the roots are fibrous.

The genus, as here regarded, consists of seven species, all native of temperate or tropical America, except *E. acaulis* (L. f.) Lindau, which is found chiefly in Africa. *Elytraria squamosa* (Jacq.) Lindau, widely distributed throughout tropical and subtropical America, is found also in Asia and the Philippine Islands.

KEY TO THE AMERICAN SPECIES

Flower bracts, or at least some of them, tridentate, the lateral teeth scarious, triangular or rhombic, the middle tooth awn-shaped; plant usually caulescent .... **1. E. squamosa.**

Flower bracts entire; plant acaulescent.

Scapes 15 to 35 cm. long, much exceeding the leaves.

Leaf blades oblong-elliptic, usually more than 2 cm. wide.

2. E. caroliniensis.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received June 12, 1934.

[2] Fl. Bot. Amer. 1: 9. *pl. 1.* 1803.

[3] J. F. GMELIN, Syst. Nat. 27. 1791.

Leaf blades linear-spatulate, less than 1 cm. wide. **3. E. angustifolia.**

Scapes 2 to 8 cm. long, rarely exceeding the leaves.

Leaf blades ovate, rounded or cordate at base, easily distinguishable from the winged petiole........... **4. E. tuberosa.**

Leaf blades oblong-elliptic or spatulate, gradually narrowed into the winged petiole.

Flower bracts acute, 3 to 4 mm. long; leaves densely pilose. **5. E. shaferi.**

Flower bracts long-attenuate, 1 cm. long; leaves glabrous or sparingly pilose....................... **6. E. bromoides.**

1. Elytraria squamosa (Jacq.) Lindau, Anal. Inst. Fisico-Geog., Costa Rica **8**: 299. 1895.

Verbena squamosa Jacq. Pl. Hort. Schoenbr. **1**: 3. *pl. 5.* 1797.
Elytraria tridentata Vahl, Enum. Pl. **1**: 107. 1804.
Elytraria frondosa H. B. K. Nov. Gen. & Sp. **2**: 234. 1817.
Elytraria fasciculata H. B. K. Nov. Gen. & Sp. **2**: 235. 1817.
Elytraria ramosa H. B. K. Nov. Gen. & Sp. **2**: 235. 1817.
Elytraria scorpioides Roem. & Schult. Syst. Veg. Mant. **1**: 128. 1822.
Elytraria apargiifolia Nees in DC. Prodr. **11**: 65. 1847.
Elytraria microstachya Oerst. Nat. For. Kjöbenhavn Vid. Medd. **1854**: 114. 1854.
Elytraria pachystachya Oerst. Nat. For. Kjöbenhavn Vid. Medd. **1854**: 116. 1854.
Tubiflora squamosa Kuntze, Rev. Gen. Pl. **2**: 500. 1891.
Tubiflora pachystachya Kuntze, Rev. Gen. Pl. **2**: 500. 1891.
Elytraria tridentata wrightii Gomez, Anal. Hist. Nat. Madrid **23**: 280. 1894.

The type locality of *Verbena squamosa* is unknown. The other species listed above were all based on specimens from tropical America.

RANGE: Arizona and Texas; Mexico and Central America; West Indies; northern and western South America; India; Philippine Islands.

A widely distributed species, extremely variable in its habit of growth. Although occasionally acaulescent and composed of a single spike-tipped scape arising from a rosette of basal leaves, the plant commonly develops a subligneous stem reaching several decimeters in length. From the tip of the stem there usually branches a cluster of scapes bearing from one to several spikes, or instead of spikes a cluster of leaves and secondary scapes, a proliferous condition, thus resulting. The scapes and stems may be simple, or branched in an irregular fashion. This method of growth often produces plants composed of an intricate mass of scapes and spikes which may be, at maturity, entirely devoid of foliage.

A marked variation is to be found also in the leaf blades. Typically oblong to oblong-obovate and 1 to 2 cm. wide, they become at times narrowly linear. Again, very broad leaves essentially ovate in outline are sometimes produced. The margin may be entire or sinuate-dentate. Other marked

variations in size and shape are to be found in the spikes and flower scales. The scarious lateral teeth of the flower bracts may be conspicuous and well developed, or almost if not entirely obsolete.

Fig. 1.—*Elytraria tuberosa* Leonard, sp. nov. A, plant ×½; B, flower bract ×2; C, calyx ×2.

2. **Elytraria caroliniensis** (Walt.) Pers. Syn. Pl. **1**: 23. 1805.
Anonymos caroliniensis Walt. Fl. Carol. 60. 1788.
Tubiflora caroliniensis Gmel. Syst. Nat. **27**: 1791.
Elytraria virgata Michx. Fl. Bor. Amer. **1**: 9. *fig. 1.* 1803.
Elytraria cupressina Nees in DC. Prodr. **11**: 65. 1847.
Elytraria virgata vahliana Nees in DC. Prodr. **11**: 65. 1847.
Elytraria virgata latifolia Nees in DC. Prodr. **11**: 65. 1847.

TYPE LOCALITY: Carolina.
RANGE: Coastal plain from South Carolina to Florida.

A species well marked by its large basal leaves and stout virgate scape, tipped by one or more spikes. It is a pine-barren plant frequenting damp sandy woods or thickets.

3. **Elytraria angustifolia** (Fernald) Leonard
Elytraria virgata angustifolia Fernald, Bot. Gaz. **22**: 169. 1896.
Elytraria caroliniensis angustifolia Blake, Rhodora **17**: 131. 1915.
Tubiflora angustifolia Small, Fl. Miami 168. 1913.

TYPE LOCALITY: Thin calcareous soil near Biscayne Bay, Florida. Type collected by A. H. Curtiss (no. 5494).

RANGE: Southern Florida.

Easily recognized by its long, very narrow leaf blades, but in other respects scarcely distinguishable from *E. caroliniensis.* A plant of low swampy regions.

4. Elytraria tuberosa Leonard, sp. nov.

Herba, radicibus tuberiformibus; foliis cum petioli late alato undulato, ovatis, apice obtusatis, basi subcordatis, margine undulato; bracteis oblongis acuminatis.

Acaulescent; roots fusiform-tuberous, 4 mm. thick; leaf blades ovate, 2 to 7 cm. long, 1.5 to 5.5 cm. wide, obtuse at apex, subcordate or occasionally truncate at base, thin, undulate, glabrous except the costa and lateral veins (usually six) which are sparingly pilose; petiole broadly winged, 3 to 15 mm. wide at apex, gradually narrowing to base, the margins undulate; scape up to 4 cm. long, clothed with firm clasping oblong-ovate acuminate ciliate scales about 6 mm. long and 2 mm. wide; spikes solitary or several, terminal, up to 3.5 cm. long and 1 cm. wide; bracts oblong, 8 to 9 mm. long, 2.5 mm. wide, acuminate, firm, faintly 3-nerved, ciliate; bractlets lanceolate, about 5 mm. long, 1 mm. wide, carinate, the keel and margin ciliate; calyx segments lanceolate, 7 to 8 mm. long, 1.5 to 2 mm. wide, acuminate, thin, faintly nerved, pilose at tip, the outermost segment bidentate; corolla 1 cm. long, the tube slender, the upper lip rounded, the lower 3-parted, the segments lobed; capsule oblong, 5 mm. long, 2 mm. broad at base, conical.

Type in the U. S. National Herbarium, no. 1,320,344, collected at El Recreo, Province of Manabi, Ecuador, by H. von Eggers (no. 15405).

Easily recognized by its thin ovate subcordate leaf blades and thickened fusiform roots. This and *E. squamosa* are the only species of *Elytraria* reported from South America.

5. Elytraria shaferi (P. Wils.) Leonard

Tubiflora shaferi P. Wils. Mem. Torrey Club **16**: 111. 1920.

TYPE LOCALITY: Pinelands, Sierra Nipe, near Woodfred, Oriente, Cuba. Type collected by Shafer (no. 3562).

RANGE: Cuba.

Elytraria shaferi is closely affiliated with *E. bromoides,* but can be separated from that species by its small bracts and pilose leaf blades. In *E. bromoides* the bracts (5 or 6 mm. long and 1 mm. wide) taper to a slender point, and the leaf blades are glabrous throughout or the costa and lateral veins sometimes sparingly pilose. The bracts of *E. shaferi* are, in contrast, merely acute and only half as large.

6. Elytraria bromoides Oerst. Nat. For. Kjöbenhavn Vid. Medd. **1854**: 115. 1854.

Tubiflora acuminata Small, Fl. Southeast. U. S. 1082. 1903.

TYPE LOCALITY: Pital, Mexico. Type collected by Liebmann. The type locality of *Tubiflora acuminata* is Texas.

RANGE: Texas, Mexico.

The entire bracts readily distinguish this from *E. squamosa*, the only other species found within its range.

PALEOBOTANY.—*Extension of range of* Attalea olssoni.[1] EDWARD W. BERRY, The Johns Hopkins University.

A single specimen of *Attalea olssoni* sent to me recently by Dr. A. A. Olsson extends the range from near the top of the middle Eocene into the Oligocene of northwestern Peru, and also discloses something of the character of the seeds.

The species was described in 1926 and referred to the genus *Astrocaryum*.[2] Subsequent material which showed more complete

Fig. 1.—*Attalea olssoni* Berry. Natural transverse section.

preservation led to its being transferred to the genus *Attalea*, and the present specimen serves to confirm this identification.[3]

All of the specimens of this species hitherto collected by myself or others have shown no trace of internal structure and have been filled with matrix or partially occupied by crystallized calcite or geodes. The present specimen is a natural section exposing two seeds and clearly indicating that three were normally present. This confirms the identification of the specimens as belonging to the genus *Attalea* instead of to *Astrocaryum* with which they were at first confused.

The present specimen shows the base and peduncle scar and the characteristic surface features corresponding to those shown by the

[1] Received August 20, 1934.

[2] BERRY, EDWARD W. U. S. Natl. Museum Proc. 70^3: 1, *pl. 1, figs. 1–4.* 1926.

[3] BERRY, EDWARD W. Pan-Amer. Geol. **51**: 242, *figs. 4–10.* 1929.

type material from the Restin formation. The distal part of the fruit is gone so that the general form is undeterminable, although it could hardly have been as elongated as in some of the Restin specimens. However there is a large amount of variation in this feature among the latter. It would be possible to differentiate several species if form were considered to have any specific value which, from the actual evidence of the fossils and from the analogous variation in the fruits of Recent palms, it clearly has not.

Among the existing species, of which there are more than a score, there may be 1, 2, or 3 seeds, and in some cases as many as 6 are said to be present. One is justified in considering that 3 seededness is a more primitive condition than a less or greater number.

The present specimen is of interest in addition to the evidence it furnishes regarding the seeds, since it shows a considerable extension of the range. All of the previous specimens were collected from an exposure just south of Punta Arena which was referred to the Restin formation, and is considered to be of late middle or early upper Eocene age.

The present specimen comes from a locality some 20 miles further south in the Chira Valley, northwest of Casa Saman, which is referred to the lower Mirador sandstone of the Mancora formation, and considered to be of Oligocene age.

ETHNOLOGY.—*A negro peyote cult.*[1] Mrs. MAURICE G. SMITH, Bureau of Indian Affairs. (Communicated by JOHN R. SWANTON.)

Those who have been interested in the fortunes of the religious organization revolving about the use of peyote have been alert for indications that it might have taken root at some time either among whites or negroes who live in close proximity to one of the peyote groups. Nowhere has an entire group of white people been found devoting themselves to the cult though frequently individuals have been interviewed who have attended meetings, and who profess devotion in varying degrees to the peyote religion.[2] These persons are usually impressed by the cures that the herb appears to effect. Some have apparently experienced the peculiar state, the nature of

[1] Received June 16, 1934.

[2] Among the notes left by James Mooney in the Bureau of Ethnology is a very interesting manuscript entitled *The peyote road: An exegesis of the religion and mystic rites of the North American Indian,* by C. S. Simmons. Mr. Simmons lived at Cache, Oklahoma and having attended many meetings over a period of years had become well versed in the doctrines of the cult. Chapter VIII on *Physical and psychical phenomena* is particularly interesting.

which has been described by some investigators[3] and which the Indians almost invariably describe as "feeling good." In how many cases this is accompanied by visionary experiences, auditory-visual impressions, or the other sensory illusions mentioned by Klüver,[4] Ellis[5] and others the present state of our knowledge does not permit us to say.

In the fall of 1930 an Iowa Indian gave Dr. Smith a lead regarding a negro peyote group which the writer endeavored to follow up in the spring of 1931. After much fruitless inquiry in both Oklahoma City and Tulsa, Okla., the daughter of the negro leader was finally located in the latter city. Her father, John Jamison, had died in 1926 as a result of concussion of the brain after being struck by "a half-crazed negro." The cult did not survive his death.

From the daughter Mabel it was learned that the cult never became very popular outside of a small group, though now and then the meetings were attended by persons who were attracted by the healing and doctoring which Jamison sometimes attempted just as the Indians do. Even some of the devoted ones became suspicious of the new religion when they learned that the government had taken steps to prohibit the transportation of peyote. "They figured there must be something wrong with it or the government would not prohibit its transportation," Mabel remarked. This attitude on the part of the negroes is doubly interesting in view of the rebellious attitude which the Indians displayed under the same circumstances, and their resort to illegal procedures to obtain peyote.

Jamison was born in Lincoln County, Oklahoma. Both of his parents were evidently alloted and, consequently, Jamison grew up among Indians.[6] He had worked for a number of them, including the Iowa who first gave us the lead, and who seemed to resent the fact that negroes were taking up "the old Indian religion."[7] His daughter claimed that he spoke several Indian languages mentioning particularly Iowa, Pawnee, and Comanche. She also testified to the

[3] Klüver, Heinrich. *Mescal: The divine plant.* London. 1928.
Dixon, W. E. *The physiological action of the alkaloids derived from Anhalonium lewinii.* Journ. of Physiology. **25**: 69–86. 1899.

[4] Klüver, Heinrich. *Mescal visions and eidetic vision.* Jour. of Amer. Psychology **37**: 502–515.

[5] Ellis, Havelock. *A note on the phenomena of mescal intoxication.* Lancet, London. **1**: 1540–1542.
Ellis, Havelock. *Mescal: A study of a divine plant.* Popular Sci. Monthly **61**: 52.

[6] During the delirium which preceded his death he sang Indian songs and prayed all the time, the nurses in the hospital informed Mabel.

[7] My informant remarked that the older Indians were more friendly toward the colored people than the younger Indians.

fact that he was "some talker" and that he was a devoutly religious man.

The ritual of the negro cult was very similar to the Indian ritual,[8] though there were, of course, some important omissions and more use of the white man's hymns and bible than is customary in Oklahoma. The meeting was continued all night, preferably in an Indian tipi. Jamison carried a canvas cover of his own along with the other paraphernalia which consisted of a drum, sacred dishes for the food served for breakfast, gourd rattle, medicine feathers, cane, sage, cedar and *chief peyote button*. He sometimes dressed in Indian costume, consisting of a feather head-dress (chief's bonnet), blanket, and sometimes moccasins. Whether or not he dressed thus when attending the Indian meetings or only after he himself became a leader and had his negro group, I did not ascertain. Nor do I know how he became a leader. Mabel said he did not become a healer and doctor till about three years before he died, but that he had meetings as far back as "before the riot" (1920, I believe) attended by both Indians and colored people which he sometimes led. At other times an Indian would be the leader. Occasionally the Indians would send for Jamison to lead their meetings.

In the center of the tipi was a fire built in front of an earth crescent. On the center of the crescent mound was the *chief peyote button* which remained there till midnight. At that time the leader ate it. The chief button is never eaten during the Indian ceremony as far as I know. The meetings began between eight and nine o'clock with the members filing in in a prescribed order to certain places. The leader faced the door of the tipi, four "sisters" on his right who took care of the morning repast, and four "brothers" on his left, the first being designated the drummer, the next the cedar man, the other two having no equivalents in the Indian ceremony. The "fireman" was placed at the right of the door and also served as doorkeeper. Jamison always had the same doorkeeper, if possible, which was in line with the relationship existing between an Indian peyote chief and his fireman. The meeting proceeded as follows:

1. The leader sang a song, usually a hymn, but if Indians were present he sang an Indian song. The leader, sitting "goat fashion,"[9] then announced the purpose of the meeting and prayed.

[8] Cf. Günter Wagner's study of the peyote cult entitled, *Entwicklung und Verbreitung des Peyote-kultes*, ein Beitrag zum problem der Akkulturation, Hamburg, 1931.

[9] The manner of sitting while the leader is opening the meeting is considered very important by the Indians. He must sit resting on his knees. This is also the position which everyone must take when eating the peyote any time during the night and is known as "goat fashion."

2. Scripture passage read by the leader or one of the male helpers. Toward morning one of the members talked on this passage.

3. Peyote passed to everyone by one of the sisters and eaten. The order of passing was from right to left. The order among the Indians is from left to right, but Mabel was certain she was correct on this point.

4. Then followed a period of speaking, praying, and singing. Questions of a religious nature might be asked and answered. At midnight the leader ate the chief peyote button, but I do not know whether this was done before or after 5.

5. At midnight the leader burst the heart of the fire. This signified the end of the day and was done in the following manner: As the sticks of the fire burned down the ashes assumed a rough heart shape, though it was very open at one end. While the midnight song was being sung, the leader took the fireman's fire-sticks and made these ashes more heartshaped after which he deliberately destroyed the heart by smoothing the ashes to the sides except for a few live coals with which a new fire was built. In the Indian ceremonies no one but the fireman ever touches the fire.

6. Water which had been standing near the door during the first part of the ceremony was now passed to the chief who drank and passed it right. This was equivalent to the Indian "Midnight water ceremony."

7. A recess for 15 or 20 minutes followed. Participants might leave the tipi via the right and eat fruit or anything else *provided* it was not salty. No Indian ceremony I have attended makes allowance for formal recess though the participants may leave when they desire if they ask permission of the leader.

8. Drummer summoned devotees by beating on the drum when the leader signified that the recess was ended. The rest of the night was spent in singing and praying and eating peyote if anyone wished more. It had been passed perhaps several times before midnight. When the leader saw the sun rising the door was thrown open and everybody stood and sang the closing song which was usually *Till we meet again*, if Jamison was running the meeting. In the Indian ceremony the leader always sings the *Quitting Song* alone. Incidentally, the fire was supposed to be built so that the sun's rays struck the center of the "heart" of the fire. The four sisters then departed, but soon returned with the morning repast which had been prepared the evening before and consisted of four dishes, all of which must be *saltless* and *sweetened*. First there was fruit, then beef prepared in the Indian way, either fresh roasted meat ground up and sweetened, or dried meat soaked, stewed, ground up, and sweetened. Next, cereal or mush and last, dried corn parched, soaked, and sweetened. The order of partaking of these foods does not seem to have been as important as in the Indian ceremonies. The service ended with another drink of water passed ceremoniously as before and "everybody was happy."

The negro ritual differed from the Indian in a few other details. In the first place, there was no ceremonial smoking of cigarettes and very little smoking with cedar. Both of these customs bulk large in most of the peyote rituals. By the latter I refer to the practise of throwing cedar on the fire at intervals and the members wafting the smoke which arises back upon themselves by means of the feathers. Cedar was only put on the fire once in the negro service by the cedar man appointed by Jamison for this purpose. It was done when the first pile of sticks on the fire had burned completely down. Feathers were always part of Jamison's regular equipment but they served more important functions in his "doctor" meetings. The drum was

used for all the singing, but the rattle only for the Indian songs. The leader held the ceremonial cane in his left hand during the entire ceremony, while the Indians pass the cane along with the drum and rattle around the circle to those who sing.

Jamison always took epsom salts Friday night before the meeting on Saturday and a hot bath before going to the meeting. This was in the nature of a purification rite and in line with various similar practises among the Indians.[10] He ate no salt in the evening meal before the meeting. "If these rules were followed they didn't see spooks or crazy things," Mabel remarked.

Further evidence of the syncretization process will be seen in the following confession of faith which was printed and hung framed in Mabel's parlor. All the devoted ones possessed such a form.

David Walker
Director

Our Motto: "The World for Christ"
Christ the Good Shepherd

picture[11]

Church Covenant
of the Church of the First born

"Hebrews 12th Chapter, 23rd verse"

We, the undersigned believers in Christ Jesus, do by virtue of Scriptural Faith submit ourselves to the cause of Christ and the gospel; to live therein; to walk therein; to teach therein; to sing therein; to pray therein; to preach therein; to baptise therein; to observe all the ordinances of Him who has called us to peace, that God may have the glory thereof.

In testimony whereof we the undersigned hereunto set our hands, by virtue of our own free will.

John C. Jamison
Conductor in Charge

Mrs. Lucinda Walker
Mother of the Household of the Faith

Mrs. J. L. Ramsey
Assistant

Katie Hoggins
Secretary of the Household of the Faith

Mrs. Polly Marshall
Assistant

It will be noticed that there is no mention of peyote in this covenant. But this is no different from the practise followed by the Indians in incorporating their peyote cult under the name of the Native American Church. Jamison had not succeeded in getting his group incorporated.

[10] The Osages build a sweathouse as an integral part of their peyote Church set-up. This is situated directly east of the octagonal-shaped church building and still farther east and in direct line with the center of the altar inside the church is the fireplace upon which the stones are heated.

[11] This is a picture of the negro group sitting goat-fashion or standing around the little ceremonial fire. In the foreground may be seen the peyote drum and other paraphernalia.

Those acquainted with the variations in the peyote ceremony in the different tribes, both in and out of Oklahoma, will recognize the many similarities and other differences which I have not mentioned in this interesting attempt to adapt the religious cult of one racial group to the needs of another.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

257TH MEETING

The 257th meeting of the ACADEMY was a joint meeting with the Philosophical Society, held in the Assembly Hall of the Cosmos Club on Saturday, March 3, 1934. About 115 persons were present. President TUCKERMAN called the meeting to order at 8:20 and introduced Prof. JAMES FRANCK, Nobel Laureate, formerly head of the Second Physical Institute, University of Gottingen. His subject was *Remarks on Catalysis.*

As an introduction, explanations were given of the conceptions: heat of reaction and catalysis.

It is possible, for a few catalytic reactions, to follow the intermediate stages of the reaction and thus to make clear why catalytic reactions do not involve larger heats of activation than is found to be the case. Two types of reactions were presented to illustrate this:

(1) The heterogeneous catalysis of reactions between hydrogen and other molecules on the surface of palladium, nickel, iron, etc.

(2) The catalytic influence of ions of heavy metals in auto-oxidation processes as presented in papers of Franck and Haber, and Haber and Wilstätter.

Type 1.—Coehn has shown that hydrogen absorbed in palladium is dissociated and ionized. This occurs to some extent in nickel and iron. Using a cycle-process, it is possible to calculate the energy liberated by the absorption of protons in palladium. The result is a large excess of energy. To account for the greater part of this energy, it was proposed to assume that there is a condensation of a cloud of free electrons around the proton, analogus to the Debye cloud formation of ions in strong electrolytes. The assumption agrees well with recent determinations of the ratio of the mobility of these ions to their diffusion (Duhm). In accordance with Schmidt, the conclusion was drawn that metals with small values of atomic volume have high values for the heat of condensation of electrons and protons. This heat of condensation is available for dissociation and ionization of the hydrogen in the metallic solution. The metals act as catalyzers because the formation of hydrogen in the gaseous state from the dissolved state takes place very easily. The transition begins with the formation of atoms from protons and electrons. The atoms in the region of the surface are unstable and here react with small heats of reaction with other molecules if these are present, that is, if they are absorbed.

Type 2.—The catalysis of SO_3^{--} ions to SO_4^{--} ions in the presence of Cu^{++} ions was discussed in greater detail. This process explains also the auto-oxidation of organic substances in the presence of Fe^{+++} ions in aqueous solutions.

Cu^{++} and Fe^{+++} ions in water are at their upper limit of stability. Impacts with molecules only slightly less stable than water will produce an exchange of an electron, the metal ion, thereby, having its charge decreased, and the molecule becoming a radical. These radicals react with oxygen forming new radicals, and chain reactions result. The metal ions are oxidized back to their states of higher electric charge. (*Author's abstract.*)

258TH MEETING

The 258th meeting of the ACADEMY was held in the Assembly Hall of the Cosmos Club at 8:15 P.M., on Friday, April 20, 1934. About fifty persons were present. President TUCKERMAN introduced Dr. KURT GODEL, Privat Dozent, University of Vienna, who spoke on the subject, *Can mathematics be proved consistent?*

CHARLES THOM, *Recording Secretary*

RECENTLY ELECTED TO MEMBERSHIP IN THE ACADEMY

ERRETT C. ALBRITTON, professor of physiology, George Washington University, was elected to membership in recognition of his contributions to physiology.

ERNST ARTSCHWAGER, pathologist, Division of Sugar Plants, Bureau of Plant Industry, was elected to membership in recognition of his contributions to plant anatomy and cytology.

NORMAN BEKKEDAHL, assistant chemist, National Bureau of Standards, was elected to membership in recognition of his contributions to electrochemistry and to the thermodynamics of rubber, and in particular of his study of the phase changes in rubber.

PAUL W. BOWMAN, assistant professor of botany, George Washington University, was elected to membership in recognition of his contributions to botany and in particular of his studies of peat bogs.

FREDERICK E. BRASCH, chief, Smithsonian Division, Library of Congress, was elected to membership in recognition of his contributions to the history of science and astronomy, and for the preparation of bibliographies of scientific literature.

RONALD BULKLEY, physical chemist, Socony-Vacuum Corporation, Paulsboro, N. J., was elected to membership in recognition of his contributions to rheology and lubrication, and particularly of his researches on extremely thin films and the thixotropy of lubricants.

BENJAMIN G. CHITWOOD, assistant zoologist, Bureau of Animal Industry, was elected to membership because of his contributions to nematology, parasitology, and animal histology.

VINCENT DU VIGNEAUD, professor of biochemistry, and executive officer, Department of Biochemistry, George Washington University, was elected to membership in recognition of his contributions to the chemistry of carbohydrates, insulin, and cystine and its homologues.

HENRY E. EWING, entomologist, Bureau of Entomology, was elected to membership in recognition of his achievements in the field of applied entomology, taxonomy of mites, and parasitology.

ARNO CARL FIELDNER, chief engineer, Experiment Stations Division, U. S. Bureau of Mines, was elected to membership in recognition of his contributions to the technology of fuels.

GEORGE R. GREENBANK, associate chemist, U. S. Department of Agriculture, was elected to membership in recognition of his studies on the oxidation of fats and oils.

LAWRENCE R. HAFSTAD, associate physicist, Department of Terrestrial Magnetism, Carnegie Institution, was elected to membership in recognition of his contributions to the field of nuclear physics.

FRANCIS E. JOHNSTON, associate professor of mathematics, George Washington University, was elected to membership in recognition of his contributions to the field of algebra and particularly the theory of finite groups.

WENDELL H. KRULL, assistant parasitologist, Bureau of Animal Industry, was elected to membership in recognition of his work in parasitology.

M. B. MATLACK, associate chemist, Bureau of Chemistry and Soils, was elected to membership in recognition of his contributions to phytochemistry.

M. A. McCALL, principal agronomist in charge, Division of Cereal Crops and Diseases, Bureau of Plant Industry, was elected to membership in recognition of his contributions to agronomy and botany, particularly for his discoveries in the structure of the embryos and young plants of wheat.

EARL B. McKINLEY, dean of the School of Medicine, George Washington University, was elected to membership in recognition of his publications relating to bacteriophage, immunology, tropical diseases, encephalitis, leprosy and syphilis.

EDWIN T. McKNIGHT, associate geologist, U. S. Geological Survey, was elected to membership in recognition of his contributions to stratiography and areal geology.

LELAND W. PARR, associate professor of bacteriology, School of Medicine, George Washington University, was elected to membership in recognition of his contributions to the application of immunological methods to the anthropology of the near East and for work with the International Health Board.

EMMETT W. PRICE, parasitologist, Bureau of Animal Industry, was elected to membership in recognition of his contributions to helminthology, especially the taxonomy of trematodes.

CHARLES F. ROSS, director of research, National Recovery Administration, was elected to membership in recognition of his contributions to the mathematical theory of economics.

J. H. ST. JOHN, major U. S. A., director, Department of Protozoology, Army Medical School, was elected to membership in recognition of his contributions in protozoology.

THOMAS D. STEWART, assistant curator, Division of Physical Anthropology, U. S. National Museum, was elected to membership in recognition of his contributions to physical anthropology, particularly Eskimo osteology and primate myology.

LAWSON E. YOCUM, assistant professor of botany, George Washington University, was elected to membership in recognition of his contributions to plant physiology, especially in the field of seed and seedling physiology.

DONNELL B. YOUNG, professor of zoology, George Washington University, was elected to membership in recognition of his contributions in the field of protozoology.

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

Notes

Smithsonian Institution.—The Smithsonian Institution commemorated on August 22 the hundredth anniversary of the birth of SAMUEL PIERPONT LANGLEY, for many years its secretary, and noted pioneer in the science of aerodynamics and the art of aviation.

Dr. ALES HRDLICKA, curator of physical anthropology at the U. S. National Museum, led a party of five students in archaeology to renew his explorations of early culture sites on Kodiak island.

AUSTIN H. CLARK, curator of echinoderms at the U. S. National Museum, has re-discovered the long-lost caterpillar of the gold-banded skipper butterfly, which had not been seen since it was first described by JOHN ABBOT in 1790.

Studying the killing effects on algae of eight different wavelengths in the ultraviolet, FLORENCE E. MEIER discovered that each had its own specific "radiotoxic spectral sensitivity," that is, its minimum quantity that would sooner or later result in death. Each wavelength also had a specific "radiotoxic virulence"; that is, the measure of time required to produce the killing effect. The two qualities are not necessarily combined in the same wavelengths.

A large collection of *Plesippus* fossils, from Pliocene strata near Hagerman, Idaho, has been excavated by C. LEWIS GAZIN of the U. S. National Museum. They are being brought here for preparation.

U. S. Department of Agriculture.—Dr. JOHN R. MOHLER, chief of the Bureau of Animal Industry, was elected president of the Twelfth International Veterinary Congress, held in New York City August 13 to 18. Six members of the Bureau presented papers, among them Dr. MAURICE C. HALL, who urged international action in combatting the spread of animal parasites, and Dr. A. E. WIGHT, who upheld the American method of eradication as a means for the control of bovine tuberculosis.

Gonad transplantations had relatively little effect when tried on cattle in a series of experiments performed by Dr. FRED W. MILLER, R. R. GRAVES and Dr. G. T. CREECH of the Department. Their results are not in accord with the claims made for the Voronoff operation on livestock, which has been widely used especially in France and the U.S.S.R.

Implants of normal ovarian and testicular tissue from cattle and pigs were made respectively in cows and bulls of various ages and conditions of health. Results were almost completely negative.

The destruction of all wild mammals except deer over an area of 192,000 acres in Maine, necessitated because of an epidemic of rabies among the foxes, will be made the occasion for a special study by members of the Bureau of Biological Survey, on the response of game and song birds to the total suppression of predators that normally keep their numbers reduced.

The Weather Bureau, with the aid of over 200 temporary employees furnished by the Civil Works Administration, has completed the compilation of a great mass of normal rainfall data for about 4,500 stations, based on the 35-year period 1898–1932. The compilation will probably not be published in its entirety in the near future, but the information is now accessible in Washington to any student who can use it.

U. S. National Park Service.—Director ARNO B. CAMMERER returned to

Washington early in September from the West, where he inspected a number of the parks and monuments. Director CAMMERER has been named to represent the United States on the International Commission on Historical Monuments. This commission was authorized at a conference of experts of the International Museums Office at Athens in 1931, and a working program was approved by the Assembly of the League of Nations in October, 1933.

ROGER W. TOLL, superintendent of Yellowstone National Park, is now in Washington in connection with the preparation of the recreation section of the Natural Resources Board report, which must be in the hands of the President by December 1 of this year. BEN H. THOMPSON of the Service's Wildlife Division at Berkeley, California, is also in Washington aiding with this report.

ELBERT COX, assistant park historian on the Colonial National Monument staff, who has been on detail to the Washington Office for the past year supervising the historical research staff and assisting chief historian CHATELAIN in the preparation of educational programs in the historical parks and other military areas, has been appointed superintendent of the Morristown National Historical Park in New Jersey.

Children's Bureau, U. S. Department of Labor.—A study of the comparability of maternal mortality rates, dealing particularly with similarities and differences in different countries of assigning cause to deaths certified to be associated with pregnancy and childbirth, and the effect of such differences upon the comparability of the figures of the United States and 16 foreign countries has been completed and the report, written by Dr. ELIZABETH C. TANDY, director of the Statistical Division of the Children's Bureau, is ready to go to press.

In an effort to determine the effect of various forms of treatment during the early weeks of life, the child and maternal health division of the Children's Bureau is making a study of the care and treatment of premature infants born at the New Haven Hospital during the past $7\frac{1}{2}$ years. Careful analysis of the cause of death is being made in the case of those infants who died. As approximately half of the 85,000 neonatal deaths occurring each year in the United States are due to prematurity, it is apparent that study of the problem of prematurity and provision of better care of the premature infant are urgently needed.

During the month of September a physician from the staff of the Children's Bureau will examine 200 Indian children in the pueblos near Santa Fe, New Mexico, as part of a three-year investigation being carried on by the Santa Fe Anthropological Laboratories and the Office of Indian Affairs of the Interior Department. The children will be studied from the point of view of growth and development and physical health. In addition special studies of dental development and the incidence of tuberculosis will probably be made. The pediatrician from the Children's Bureau will make the physical examinations and assist with the tuberculosis studies.

Carnegie Institution of Washington.—Arrangements have been made through the Department of Terrestrial Magnetism of the Carnegie Institution of Washington for the latter's Cosmic-Ray Committee, in cooperation with the United States Coast and Geodetic Survey, to install an automatic-recording cosmic-ray meter at the Cheltenham Magnetic Observatory, Maryland, in September or October 1934.

Dr. L. R. Hafstad of the Department of Terrestrial Magnetism sailed September 5 to attend the meeting of the International Union of Scientific Radiotelegraphy in London (September 12–19) and the joint meeting of the International Union of Pure and Applied Physics with the London Physical Society, also in London (October 1–6). He will take part in a symposium on nuclear physics during the latter meeting and will present several communications for the Department on investigations of the ionosphere to the former.

Prof. G. Gamow of the Polytechnical Institute, Leningrad, spoke on some new conceptions of the structure of the nuclei at the Department of Terrestrial Magnetism, September 4 and 10.

Development of standards.—An examination of the first 496 codes approved by the National Recovery Administration reveals that 195 of them, or 41 per cent, have provisions for standards of some sort, according to a report to the American Standards Association, cooperating with the National Bureau of Standards. Ninety-three industries desire standards but have yet to obtain them.

Out of the 496 codes examined, 63 demand standardization on the basis of the work of some government agency. The specific agencies cited as authorities for standards include: the National Bureau of Standards, The American Standards Association, The American Society of Testing Materials, Federal Trade Commission, U. S. Public Health Service, U. S. Department of Agriculture and the Interstate Commerce Commission, together with trade associations which have done prior pioneer work in establishing their own industrial standards.

New type beacon reflector.—The slash in the budget of the Bureau of Air Commerce a year ago led to the development of a new type reflector for airplane beacons which enables a 500 watt electric light bulb to outshine the 1,000 watt bulbs formerly used. Last year the beacons on the Federal Airways system used 1,000 watt, 1,600,000 candlepower lamps with prismatic cover glasses. The order for economy came through and the lamps were changed to 500 watt bulbs. The candlepower went down to 750,000. At the same time, however, the National Bureau of Standards was ordered to investigate ways of increasing the lighting power of the 500 watt lamps. F. Chapin Breckinridge, of the Bureau, made tests on various types of 500 watt lamps, cover glasses and auxiliary reflectors. The final result is a beacon with a 500 watt bulb, plain cover glass and a new type auxiliary reflector which yields 2,000,000 candlepower—about 25 per cent more than the old 1,000 watt bulbs.

Is the United States getting wider?—The distance between Washington, D. C., and San Diego, Calif., showed an apparent increase of about forty feet in 1933 as compared with measurements made seven years earlier. This discrepancy was reported at the meeting of the American Astronomical Society at Connecticut College by C. B. Watts of the U. S. Naval Observatory. Mr. Watts stated that he suspected some systematic error; it appears easier for astronomers to make an error of forty feet in measuring a line 3,000 miles long than for the United States to grow forty feet "fatter" in seven years.

News Briefs

Sodium vapor lamps have no special advantages or disadvantages when used by persons engaged in clerical work indoors, Dr. James E. Ives, senior physicist of the U. S. Public Health Service has reported, after a three months' test conducted in New York City. C.W.A. clerical workers participated in the test.

Installation of special radio receivers at filling stations and other points along motor routes to supply autoists with weather information is suggested by the Bureau of Air Commerce. Every hour 68 airways broadcast stations in the United States send out the latest weather news for the benefit of fliers. This information, often valuable for motorists, could be made available by the installation of 200 to 400 kilocycle receivers at places motorists frequent on a cross country trip.

Radio talks given under the auspices of Science Service, over the network of the Columbia Broadcasting System, were as follows: August 15, *Fighting plant diseases,* by F. C. Meier, U. S. Department of Agriculture; August 22, *Can you live without water?* by Abel Wolman, State of Maryland Department of Health; August 29, *Health and the depression,* by George St. J. Perrott, U. S. Public Health Service and Milbank Memorial Fund; September 5, *Is America about to lose her elms?* by Stanley B. Fracker, U. S. Department of Agriculture; September 12, *Harnessing scientific discoveries,* by P. G. Agnew, American Standards Association.

Personal Items

Lt.-Col. Jules Voncken of the medical service of the Belgian Army and director of the Military Hospital at Liège, arrived in Washington September 5 for a three-day visit. He is en route to Tokyo, where he will represent his country at the International Conference of Red Cross Societies. Colonel Voncken visited the Surgeons General of the Army, Navy and Public Health Service, as well as the various Government medical establishments. On September 6 a luncheon was held in his honor at the Army and Navy Club.

Dr. Isaiah Bowman, secretary of the National Research Council, was president of the International Geographical Congress which met in Warsaw during the last week in August. In his presidential address, Dr. Bowman emphasized the need for competent geographic information, if efforts to adjust present mal-distributions of natural resources among nations are ever to receive equitable readjustment.

Prof. John M. Cooper of the Catholic University of America returned early in September from an anthropological expedition among the Indians in the territory east of Hudson Bay. Father Cooper is obtaining from the older members of these primitive tribes a record of the religious beliefs they held before the coming of European missionaries.

Dr. C. F. Marvin, former chief of the Weather Bureau, U. S. Department of Agriculture, retired on August 25, after fifty years' service as a meteorologist. He had been chief of the bureau for twenty-one years.

Dr. C. F. Marbut, chief of the division of soil survey of the Bureau of Chemistry and Soils of the U. S. Department of Agriculture, who was recently appointed honorary professor of soils at the University of Missouri, left at the end of August for a conference on soils in Barcelona, after which he will participate in an excursion of soil specialists over the Spanish peninsula and part of North Africa. He plans later to spend a few months as adviser on soils to the Geological Survey of China, returning to the United States in the spring, after having spent some time in India.

Obituary

Karl Frederic Kellerman, principal bacteriologist, in charge of the Division of Plant Disease Eradication of the Bureau of Entomology and Plant Quarantine, in the Department of Agriculture, died August 30, at Washington, D. C. Dr. Kellerman was born in Göttingen, Germany, December 9, 1879. After attending Ohio State University, 1896 to 1899, he received the degree of B.S. from Cornell in 1900 and served as assistant botanist at that institution in 1901. Joining the Bureau of Plant Industry in the same year, he served successively as assistant physiologist, physiologist in charge of the Laboratory of Plant Physiology, physiologist in charge of soil bacteriology, assistant chief (1914), and associate chief (1917), remaining in the latter position until 1933 when he took up the work of directing plant disease eradication projects for the Bureau of Plant Quarantine. Dr. Kellerman was instrumental in founding the Journal of Agricultural Research and served for 11 years as chairman of its editorial board. During the War he was a member of the National Research Council. He was also a member for a number of years of the Federal Horticulture Board and took an active part in the work of that organization in carrying on plant quarantine activities. In addition to the Washington Academy of Sciences, Dr. Kellerman was a member of the American Association for the Advancement of Science, the Botanical Society of America, the Botanical Society of Washington, the Society of American Bacteriologists, the Society of Naturalists, International Society of Soil Science, and Sigma Xi. He received the degree of Doctor of Science from Kansas College in 1923.

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This JOURNAL, the official organ of the Washington Academy of Sciences, publishes: (1) short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The JOURNAL is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years.

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JOURNAL

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VOL. 24 NOVEMBER 15, 1934 No. 11

PHYSICS.—*The virial theorem for nonholonomic systems.*[1] R. J. SEEGER, The George Washington University.

The original statement[2] of Clausius' Virial Theorem is as follows: *Die mittlere lebendige Kraft des Systems ist gleich seinem Virial.* This is the same as is usually given in modern textbooks[3] despite the fact that it has been extended to include systems involving frictional forces,[4] relativistic mechanics[5] and wave-mechanics.[6] What has not been noted, however, is that each of these cases is a special form of a much more general theorem. And this is the very reason an analogous theorem can be derived that holds equally well for holonomic and for nonholonomic systems. The following proofs are given on the basis of relativistic mechanics.

Consider a holonomic dynamic system composed of m particles with mass m_i and velocity v_i. If there are n degrees of freedom, Lagrange's equations of motion (of the second form) may be written in terms of the generalized coördinates q_α, the generalized forces Q_α and the relativistic function T' as follows:

$$\frac{d}{dt}\left(\frac{\partial T'}{\partial \dot{q}_\alpha}\right)-\frac{\partial T'}{\partial q_\alpha}=Q_\alpha \qquad \alpha=1,\,2,\,\cdots,\,n$$

where

$$T' \equiv -\sum_{i=1}^{m} m_i c^2\left(1-\frac{v_i^2}{c^2}\right).$$

In this expression for T' the velocities v_i must be expressed as functions of the generalized coördinates and of the generalized velocities (c represents the velocity of light). Multiplying each of Lagrange's equations respectively by $D^K q_\alpha$, where

[1] Received August 13, 1934.

[2] CLAUSIUS, R. Ann. d. Phys. u. Chem. **2**: 124. 1870.

[3] JEANS, J. H. *The dynamical theory of gases* (4th ed. 1925). 130. LOEB, L. B. *Kinetic theory of gases* (2nd ed. 1934). 153.

[4] MILNE, E. A. Phil. Mag. **50**: 409. 1925.

[5] RUARK and UREY. *Atoms, molecules and quanta* (1930). 739.

[6] FINKELSTEIN, B. Zs. f. Phys. **50**: 293. 1927. FOCK, V. Zs. f. Phys. **63**: 855. 1930.

$$D^K q_\alpha \equiv \frac{d^K q_\alpha}{dt^K}$$

and using the identities

$$(D^K q_\alpha)\frac{d}{dt}\left(\frac{\partial T'}{\partial \dot{q}_\alpha}\right) \equiv \frac{d}{dt}\left\{(D^K q_\alpha)\frac{\partial T'}{\partial \dot{q}_\alpha}\right\} - (D^{K+1}q_\alpha)\frac{\partial T'}{\partial \dot{q}_\alpha}$$

we have

$$\frac{d}{dt}\left\{(D^K q_\alpha)\frac{\partial T'}{\partial \dot{q}_\alpha}\right\} - (D^{K+1}q_\alpha)\frac{\partial T'}{\partial \dot{q}_\alpha} - (D^K q_\alpha)\frac{\partial T'}{\partial q_\alpha} = (D^K q_\alpha)Q_\alpha$$

$$\alpha = 1, 2, \cdots, n.$$

Adding these n equations, we multiply the result by the differential of the time and integrate over a long period of time τ. Hence,

$$\int_0^\tau \sum_{\alpha=1}^n \frac{d}{dt}\left\{(D^K q_\alpha)\frac{\partial T'}{\partial \dot{q}_\alpha}\right\} dt - \int_0^\tau \sum_{\alpha=1}^n (D^{K+1}q_\alpha)\frac{\partial T'}{\partial \dot{q}_\alpha} dt$$
$$- \int_0^\tau \sum_{\alpha=1}^n (D^K q_\alpha)\frac{\partial T'}{\partial q_\alpha} dt = \int_0^\tau \sum_{\alpha=1}^n (D^K q_\alpha)Q_\alpha dt.$$

Dividing by the time τ, we have

$$\frac{1}{\tau}\left[\sum_{\alpha=1}^n\left\{(D^K q_\alpha)\frac{\partial T'}{\partial \dot{q}_\alpha}\right\}\right]_0^\tau - \frac{1}{\tau}\int_0^\tau \sum_{\alpha=1}^n (D^{K+1}q_\alpha)\frac{\partial T'}{\partial \dot{q}_\alpha} dt$$
$$- \frac{1}{\tau}\int_0^\tau \sum_{\alpha=1}^n (D^K q_\alpha)\frac{\partial T'}{\partial q_\alpha} dt = \frac{1}{\tau}\int_0^\tau \sum_{\alpha=1}^n (D^K q_\alpha)Q_\alpha dt.$$

If we now restrict the coördinates and velocities within a region of finite values, i.e., a steady state, we can take the time τ sufficiently long that the first term becomes relatively negligible, whereas the other terms represent average values. Thus

$$\frac{1}{2}\overline{\sum_{\alpha=1}^n (D^{K+1}q_\alpha)\frac{\partial T'}{\partial \dot{q}_\alpha}} + \frac{1}{2}\overline{\sum_{\alpha=1}^n (D^K q_\alpha)\frac{\partial T'}{\partial q_\alpha}} = -\frac{1}{2}\overline{\sum_{\alpha=1}^n (D^K q_\alpha)Q_\alpha}.$$

The expression on the right may be called the generalized virial and the entire relation the general virial theorem. It is customary to consider the special case for K equal to 0. Therefore

$$\frac{1}{2}\overline{\sum_{\alpha=1}^n \dot{q}_\alpha \frac{\partial T'}{\partial \dot{q}_\alpha}} + \frac{1}{2}\overline{\sum_{\alpha=1}^n q_\alpha \frac{\partial T'}{\partial q_\alpha}} = -\frac{1}{2}\overline{\sum_{\alpha=1}^n q_\alpha Q_\alpha}.$$

If T' is a homogeneous quadratic function of all the velocities $\dot{q}_\alpha$, the first term becomes simply T'. And in non-relativistic mechanics, where T' reduces to the kinetic energy T, it signifies the average energy of the system. We note, however, that this is not usually equal to the generalized virial on account of the non-momental part of the effective forces, which give rise to the term $\frac{1}{2}\overline{\sum_{\alpha=1}^{n} q_\alpha \frac{\partial T'}{\partial q_\alpha}}$ · To be sure, we can formally modify our definition of the generalized virial to include this term. But regardless of the particular choice we make, the fact remains that it must be taken into account some place. The usual form of the virial theorem is accidental in that Cartesian coördinates are employed for which $\frac{\partial T'}{\partial q_\alpha} = 0$. All the same, its simplicity of form and ease of physical interpretation render it more useful than the theorem in terms of generalized coördinates. As for the general virial theorem (K any value), it is still less convenient here, but very desirable for nonholonomic systems. Incidentally, we note that this theorem holds, not only for a steady state, but also for a periodic system if the average is taken over a time τ equal to an integral multiple of the fundamental period.

Let us now consider a nonholonomic dynamic system, i.e., one in which the essential minimum number of coördinates r is h more than the number of degrees of freedom n on account of h non-integrable relations, viz.,

$$\sum_{\alpha=1}^{r} a_{\alpha\beta} dq_\alpha + b_\beta dt = 0 \qquad \beta = 1, 2, \cdots, h$$

where $a_{\alpha\beta}$ and b_β are functions of the coördinates q_α and the time t. We can write Appell's equations of motion[7] in terms of n generalized coördinates q_γ (selected in a certain way from the all the r coördinates), modified forces Q_γ and the relativistic *energy of the accelerations* Λ as follows:

$$\frac{\partial \Lambda}{\partial \ddot{q}_\gamma} = Q_\gamma \qquad \gamma = 1, 2, \cdots, n$$

[7] SEEGER, R. J. This JOURNAL. **20**: 481. 1930.

where

$$\Lambda \equiv \frac{1}{2} \sum_{i=1}^{m} \frac{m_{i0}}{\left(1-\frac{v_i^2}{c^2}\right)^{3/2}} {}^{1}(\ddot{x}_i^2+\ddot{y}_i^2+\ddot{z}_i^2).$$

The *energy of the accelerations* must be expressed as a function of the coördinates q_γ, the velocities $\dot{q}_\gamma$ and the accelerations $\ddot{q}_\gamma$. Proceeding in the same as in the proof for holonomic systems, we finally obtain

$$\overline{\frac{1}{2} \sum_{\gamma=1}^{n} (D^{K+1}q_\gamma)_1 \frac{\partial \Lambda}{\partial \ddot{q}_\gamma}} = -\overline{\frac{1}{2} \sum_{\gamma=1}^{n} (D^K q_\gamma) Q_\gamma}.$$

Let us call the expression on the right the generalized *virial of the accelerations*. Then we have a new form of the virial theorem, which is superior to that deduced from Lagrange's equations in that it holds for both holonomic and nonholonomic systems (the former is a special case of the latter for h equal to zero). We find it convenient to take K equal to one this time. Therefore

$$\overline{\frac{1}{2} \sum_{\gamma=1}^{n} \ddot{q}_\gamma \frac{\partial \Lambda}{\partial \ddot{q}_\gamma}} = -\overline{\frac{1}{2} \sum_{\gamma=1}^{n} \dot{q}_\gamma Q_\gamma}.$$

For, if Λ is a homogeneous quadratic function of $\ddot{q}_\gamma$, the term on the left becomes $\overline{\Lambda}$. And our theorem states that the average relativistic *energy of the accelerations* is equal to the *virial of the accelerations.* This is always true for Cartesian coördinates in nonrelativistic mechanics. This theorem is as simple as the usual virial theorem. But we conclude that in both cases the simplicity is not so much inherent in the dynamic system as it is the result of a judicious choice of the type of coördinates and of the value assigned to K.

CHEMISTRY.—*5-Chloroveratralhippuric acid and some of its derivatives.*[1] RAYMOND M. HANN. Private Laboratory of J. P. Wetherill, Washington, D. C. (Communicated by R. E. GIBSON.)

In prior communications the condensation of 5-chloroveratric aldehyde with aliphatic and aromatic amides,[2] and its conversion to 3, 4-dimethoxy-5-chlorobenzoic acid through hydrolysis of the nitrile formed by acetylation of the syn form of its oxime,[3] have been de-

[1] Received September 8, 1934.
[2] HANN. This JOURNAL, 24: 125. 1934.
[3] HANN. This JOURNAL, 24: 329. 1934.

scribed. The present paper records the condensation of this aldehyde with hippuric acid to form the azlactone of 5-chloroveratralhippuric acid, and the utilization of the latter in the preparation of some of the simpler derivatives of 5-chloroveratralhippuric acid. Further study is being made of the azlactone as an intermediate in the synthesis of 3, 4-dimethoxy-5-chlorophenylpyruric acid.

EXPERIMENTAL

5-Chloroveratralhippuric acid azlactone.—A solution of 5 g. 5-chloroveratric aldehyde, 4.5 g. of hippuric acid and 2 g. of pulverized fused sodium acetate in 25 cc. of acetic anhydride was heated under reflux on the steam bath. The solution rapidly changed in color from straw yellow to deep red and a yellow precipitate formed almost at once, completely filling the solution at the end of one-half hour, when the suspension was cooled and 100 cc. of water added. The yellow solid was filtered, washed with water and dried. Yield 6.9 g. (80% of theory).

5-Chloroveratralhippuric acid azlactone crystallizes from 95% alcohol (1 g. in 200 cc.) in radiating clusters of golden yellow glistening needles which melt at 161°C. (corr.) to a clear yellow oil.

Anal.—0.1591 g. consumed 4.82 cc. 0.1 N acid equivalent to 4.24% nitrogen. Theory for $C_{18}H_{14}O_4NCl$ is 4.08% nitrogen.

5-Chloroveratralhippuric acid.—A suspension of 3 g. of the azlactone in 30 cc. water and 7 cc. of 10% NaOH was refluxed for one-half hour when a clear solution resulted. The cold solution was acidified with dilute hydrochloric acid and the precipitated acid filtered, washed with water and dried. Yield 2.7 g. The acid was practically insoluble in water and was recrystallized from twenty parts of 50% alcohol for analysis.

5-Chloroveratralhippuric acid crystallizes in colorless, glistening needles melting at 192°C.

Anal.—0.1493 g. consumed 4.12 cc. 0.1 N acid equivalent to 3.86% nitrogen. Theory for $C_{18}H_{16}O_5NCl$ is 3.87% nitrogen.

5-Chloroveratralhippuramide.—A suspension of 2.5 g. of azlactone in 20 cc. of 95% alcohol and 10 cc. of strong ammonia solution in water was gently heated on the steam bath. The solution rapidly lightened in color and the yellow needles of azlactone were replaced by shining, colorless leaflets. After one-half hour 50 cc. of water was added and the precipitate filtered off and recrystallized from 150 cc. of 95% alcohol. Yield 2.1 g.

The substituted hippuramide crystallizes in microcrystalline, glist-

ening platelets melting at 213–4°C. (corr.) to a red oil with considerable decomposition. It is colorless when first crystallized, but becomes slightly yellow on standing.

Anal.—0.1687 g. consumed 9.44 cc. 0.1 N acid equivalent to 7.84% nitrogen. Theory for $C_{18}H_{17}O_4N_2Cl$ is 7.77% nitrogen.

5-Chloroveratralhippuramide.—One gram of the hippuramide, described above, was refluxed with 20 cc. of 10% sodium hydroxide and 30 cc. of water, the amide dissolving to give a clear intensely yellow solution. At the end of five minutes a yellow precipitate came down; the heating was discontinued, the cooled solution acidified to congo red by addition of 1:1 hydrochloric acid, and the precipitate filtered off and dried. It was recrystallized from 350 cc. 95% alcohol and was obtained in brilliant yellow needles melting at 286–7°C. (corr.) to a red tar-like liquid; this melting point remained unchanged by further recrystallization. The imide dissolves in sulfuric acid with production of an intense red color.

Anal.—0.1438 g. consumed 8.38 cc. 0.1 N acid equivalent to 8.16% nitrogen. Theory for $C_{18}H_{15}O_3N_2Cl$ is 8.18% nitrogen.

Methyl 5-chloroveratralhippurate.—Three grams of 5-chloroveratralhippuric acid azlactone were boiled under reflux with 30 cc. of anhydrous methyl alcohol and a granule of solid sodium hydroxide for eight minutes. Rapid solution and partial decolorization of the azlactone resulted and after cooling, water (18 cc.) was gradually added to bring about crystallization of the methyl ester. The yield of 2.5 g. was recrystallized from 50 cc. of 50% alcohol to constant melting point.

The methyl ester of 5-chloroveratralhippuric acid crystallizes in colorless, shining needles which melt at 135°C. (corr.) to a clear, colorless oil.

Anal.—Calcd. for $C_{19}H_{18}O_5NCl$: C, 60.70: H, 4.83.[4] Found: C, 60.69: H, 4.73, .1669 g. consumed 4.56 cc. 0.1 N acid equivalent to 3.83% nitrogen. Theory for $C_{19}H_{18}O_5NCl$ is 3.73% nitrogen.

Ethyl 5-chloroveratralhippurate.—This ester was prepared in the same manner as the methyl ester and crystallized in colorless, brilliant needles melting at 104°C. (corr.) to a clear oil.

Anal.—0.1546 g. consumed 3.95 cc. 0.1 N acid equivalent to 3.58% nitrogen. Theory for $C_{20}H_{20}O_5NCl$ is 3.60% nitrogen.

SUMMARY

5-Chloroveratralhippuric acid, its azlactone, amide, imide, and methyl and ethyl esters have been prepared and described.

[4] Appreciation is expressed to Dr. E. L. Jackson for this analysis.

BOTANY.—*Additional Costa Rican Mosses, III.*[1] EDWIN B. BARTRAM, Bushkill, Pennsylvania.

During the past three years many collections from various sources have added many new and interesting species to the Costa Rican moss flora. The number and variety of these additions indicate very plainly that the mosses of this comparatively small area are still imperfectly known. Undoubtedly further exploration, especially in the more inaccessible mountain regions, will expand the list of local species to a considerable extent. Under these circumstances it seems unwise to make up even a tentative list just yet, but I am hopeful that with the continued help of some of the active resident botanists it may be possible in the course of a few years to produce a fairly complete outline of the mosses of this rich and interesting region.

Professor Manuel Valerio, Director of the Museo Nacional in San José, continues to collect as far as his activities in the Museum will permit and expects shortly to make a trip to the Cerro del Chirripó, a practically unexplored region, from which much may be expected. As a direct result of the sustained activity and interest of Professor Anastasio Alfaro during the past year we owe the addition of many valuable records. To Señor Fed. Gutierrez, whose collections have been transmitted through the kindness of Professor Alfaro, we are indebted for an unusually valuable series of collections from the Banana River, in the low country along the Atlantic coast, which includes many novelties. The collections of C. W. Dodge and W. S. Thomas were kindly entrusted to me by Dr. Dodge for determination and a small series, including a new species of *Squamidium*, was sent in by the collector, Professor H. E. Stork of Carleton College, Northfield, Minnesota. To these gentlemen I wish to express my profound thanks. It is mainly through their efforts and cooperation that the results detailed in the following list have been made possible.

FISSIDENTACEAE

FISSIDENS MOLLIS Mitt.

Banana River, 80 m., May 23, 1934, *F. Gutierrez;* San Luís de Turribares, 450 m., Prov. San José, July 15, 1933, *M. Valerio* 359.

The agreement between these specimens and collections from the Antilles is reasonably complete, and I have but little hesitation in crediting the species to Costa Rica.

FISSIDENS KEGELIANUS C. M.

Banana River, 80 m., May 14, 1934, May 23, 1934, June 9, 1934, *F. Gutierrez.*

[1] Received July 28, 1934.

This is one of the few minute species of the section Bryoidium that seems to be fairly well defined. The enlarged, lax areolation of the duplicate blades contrasts sharply with the smaller hexagonal cells of the apical and dorsal blades and appears to be a good diagnostic character. It is an interesting addition to the local flora.

FISSIDENS GARBERI Lesq. & James.

Roadsides south of Liberia, 100 m., Prov. Guanacaste, Jan. 16, 1930, *C. W. Dodge & W. S. Thomas* 6595.

Fissidens Garberi is new to the Costa Rican flora, but these plants are not exactly typical. The costa ends considerably below the apex, which is broadly rounded in many leaves, and the leaf cells are rather obscure and more coarsely papillose with sharp papillae. As these distinctions may not be of much consequence in such a large and intricate group of species, I am inclined to refer this collection here as an unusual form.

DICRANACEAE

TREMATODON LONGICOLLIS Michx.

Tilarán, 700 m., March 15, 1934, *A. Alfaro;* La Fuente, 1200 m., Dec. 27, 1933, *A. Alfaro* 47.

This is one of the smaller forms that might be referred to *T. reflexus* C. M., but, as Mrs. Britton has remarked[2] this species is probably only a small form of *T. longicollis*. It is an interesting new record for Costa Rica and helps to bridge the gap between Guatemala and the South American stations in Brazil and Bolivia.

DICRANELLA STANDLEYI Bartr.

Additional records for this endemic species are as follows: La Fuente, 1200 m., Oct. 16, 1933 and Dec. 27, 1933, *A. Alfaro*.

DICRANELLA BARBENSIS Ren. & Card.

Coronado, 1500 m., Jan. 7, 1934, *A. Alfaro*.

Although the peristome is up to 270μ high, almost twice the height given by Mr. Williams in North American Flora, this collection, which is in prime fruit, seems without much doubt to belong here. The teeth are coarsely papillose, not vertically striate, cleft to about the middle into 2 or 3 unequal prongs, and the leaf blade is produced nearly or quite to the apex so that the costa is barely percurrent.

CAMPYLOPODIUM PUSILLUM (Schp.) Williams.

Volcán Poás, 2500 m., Jan. 4, 1934, *A. Alfaro* 52a.

A number of fruiting plants of this attractive little species were separated from tufts of *Ceratodon stenocarpus*. This is the only collection I know of from Costa Rica.

[2] North American Flora, 15: 53. 1913.

Campylopus fragilis (Dicks.) Bry. Eur.

San Jerónimo, 1400 m., Nov. 15, 1933, *A. Alfaro.*

Not previously known from Costa Rica. This species will be separated from *C. flexuosus* (Hedw.) Brid. by the absence of any differentiated alar cells; also the leaf base is more contracted to the insertion.

Leucoloma tortellum (Mitt.) Jaeg.

Upper slopes of Cerro San José de Libano, 500–960 m., Prov. Guanacaste, Feb. 15, 1930, *C. W. Dodge, R. Hanckel, & W. S. Thomas* 7918.

The range of this unique species seems to be gradually expanding. Mr. Williams restricts it to Guadeloupe and Trinidad in North American Flora. It was later found by Mr. Paul C. Standley in the Lancetilla Valley, Honduras.[3] The locality in Guanacaste Province, Costa Rica, not only helps to outline more clearly the area in which it may be looked for but also adds another interesting species to the local flora.

CALYMPERACEAE

Syrrhopodon Guadichaudii Mont.

La Fuente, 1200 m., Dec. 4, 1933, *A. Alfaro* 37.

These collections are in fine fruit and add a second locality to the Costa Rican record.

Syrrhopodon aculeo-ciliatus Bartr., sp. nov.

Figure 1.

Gracilescens, caespitosus, caespitibus laxiusculis, pallide viridibus. Caulis ad 2.5 cm. longus, basi radiculosus, dichotome ramosus vel simplex. Folia ad 2 mm. longa, sicca contorta, humida patentia, e basi vaginante auguste linearia, obtusa, limbata, limbo angusto hyalino sub apice evanido; marginibus incurvis, argute serratis, in parte superiore vaginae et summo apice dentibus aculeiformibus instructis; nervo tenui, infra apicem folii evanido, dorso scabro; cellulis laminalibus minutis rotundatis, dorso minutissime papillosis, ventri mamillosis; cancellina supra rotundata. Caetera ignota.

Dioicous? Slender plants growing in small lax tufts, pale green above, brownish below. Stems up to 2.5 cm. high, simple or forked above, sparingly radiculose near base. Leaves about 5 mm. long, flexuose, spreading, twisted and contorted when dry, widely spreading when moist, linear-lanceolate from a white, erect, narrow clasping base about 2 mm. long, gradually contracted to a linear, channelled or subtubulose point, blunt at apex, bordered from just below the apex to the base with 1-3 rows of elongate hyaline cells; margin erect or incurved, spinose-ciliate at shoulders of leaf and at apex, distantly spinose in median part of blade; costa pale and thin, about 45μ wide toward base, ending just below the apex, spinose on back toward apex, smooth below, spinose on ventral side about half-way down, in cross section near midleaf showing a median row of about 6 guide cells with stereid bands on both sides, the outer layer of cells on ventral surface well differentiated;

[3] Field Museum of Natural History, Bot. Series, 4: 352. 1929.

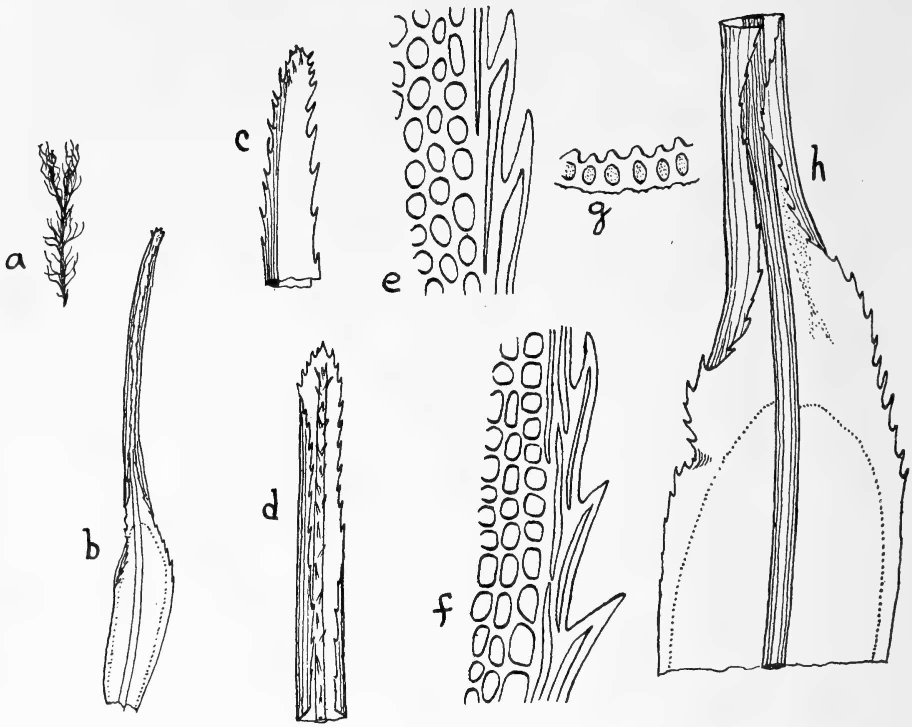

Fig. 1.—*Syrrhopodon aculeo-ciliatus* Bartr. a.—Plant ×1. b.—Leaf ×14. c.—Apex of leaf in profile ×80. d.—Apex of leaf from upper side ×80. e.—Upper leaf cells and margin ×400. f.—Cells and margin near leaf shoulder ×400. g.—Fragment of cross section from upper part of leaf ×400. h.—Part of leaf from upper side ×80.

cells of leaf blade rounded, incrassate, 6-8μ in diameter, mamillose on inner surface, minutely papillose on the back; cancellinae filling nearly all the leaf base, rounded or ending in obtuse angles above, in 8–10 rows. Sporophyte unknown.

Type: La Hondura, Costa Rica, August 15, 1933, *M. Valerio* 369a.

This species seems to be closely allied to *S. Leprieuri* Mont., but is noticably different in the pale green color, the mamillose leaf cells, and the spinose margins of the leaf blade.

Syrrhopodon parasiticus (Sw.) Besch.

Tilarán, 700 m., March 15, 1934, *A. Alfaro.*

Even though the leaves of the Costa Rican plants seem to lack entirely the narrow hyaline border of elongated cells, they agree perfectly in other particulars with collections from Florida and Yucatán and evidently represent a form of *S. parasiticus.* The characteristic filiform propagula are abundant on the inner faces of the comal leaves.

CALYMPERES LONCHOPHYLLUM Schwaegr.

Banana River, 100 m., April 27, 1934, *F. Gutierrez.*

An interesting but not unexpected addition to the local flora which assists in consolidating the geographical range of the species. This species extends to northeastern Guatemala and British Honduras.

POTTIACEAE

HYMENOSTOMUM MEXICANUM Card.

Tiribí, 1100 m., Oct. 28, 1933, *A. Alfaro.*

LEPTODONTIUM ORCUTTI Bartr.

Potreros between Guayabillos and Cabeza de Vaca, 2150–2350 m., Prov. San José, Nov. 4, 1929, *C. W. Dodge & W. S. Thomas* 4922.

Evidently this species is confined to fairly high altitudes in Costa Rica. The only other local station known is at an altitude of 3300 m., on Volcán Irazú.

BARBULA SUBULIFOLIA Sull.

Syn.: *Barbula subulirostre* Bartr. in herbaria.

San Pedro, 1170 m., Sept. 1933, *A. Alfaro* 4, 27; Banana River, 100 m., April 27, 1934, *F. Gutierrez.*

It did not occur to me to associate these collections with *B. subulifolia* Sull. until after I had distributed several packets under the new name. Further study has convinced me that all the above collections are clearly referable to *B. subulifolia* Sull., which does not seem to have been noted in Central America before. The long subulate operculum, often appreciably longer than the urn, the long, tightly twisted peristome teeth, the subulate leaf points (usually obtuse and toothed at the apex), and the smooth quadrate leaf cells are fairly stable characters in the aggregate, but the leaves vary considerably in outline and it is probable that a number of nearly related "species" from the Antilles will eventually find their way into the synonymy of *B. subulifolia.*

BARBULA CRUGERI Sond.

Banana River, 80 m., May 20, 1934, *F. Gutierrez.*

New to Costa Rica, so far as I know. This well known and easily recognized species is common in the Antilles but apparently very rare in Central America. It appears again, like so many other Caribbean types, in the Andes of South America. The geographical distribution of these species seems to be in the form of a narrow band extending directly north and south through Colombia, western Venezuela, eastern Costa Rica, and the Greater Antilles to Cuba, with a few extensions to Florida and the northern shores of the Gulf of Mexico.

Tortula mniifolia (Sull.) Mitt.

Banana River, 80 m., May 23, 1934, *F. Gutierrez.*

Only the second local record for this attractive species, which ranges from Cuba to Peru.

Tortula caroliniana Andrews.

San Ildefonso, 1500 m., Jan. 21, 1934, *A. Alfaro;* Volcán Barba, 2250 m., March 11, 1934, *A. Alfaro.*

In these collections the propagula are often scattered over the ventral surface of the leaf toward the apex, rather than congested in apical clusters, but in other respects the plants agree perfectly with the species.

SPLACHNACEAE

Splachnobryum obtusum C. M.

Banana River, 80 m., April 27 to May 20th, 1934, *F. Gutierrez.*

Five packets are included here in a collective sense without any great assurance that they are all representative of one specific type. The plants with leaves from 1 to 1.2 mm. long, are all more robust than *S. Bernoullii* C. M., but there is considerable variation in the length of the stems, the crenulation of the leaf margins, the relative length of the costa, and the shape of the apex.

BRYACEAE

Brachymenium Standleyi Bartr.

Coronado, 1500 m., Jan. 7, 1934, *A. Alfaro;* San Ildefonso, 1500 m., Jan. 21, 1934, *A. Alfaro.*

Brachymenium bulbiferum Bartr., nom. nov.

Syn.: *Brachymenium viviparum* Bartr. Cont. U. S. Nat. Herb. **26: 77.** 1928. Not *B. viviparum* Ren. & Card. 1898–99.

Fuente, 1200 m., Dec. 8, 1933, A. Alfaro.

M. Theriot has kindly called my attention to the fact that the name *B. viviparum* Bartr. is preoccupied. Unfortunately the above collection fails to show any mature fruit, although the setae are well developed. Until the peristome characters are available its systematic position must remain uncertain.

Anomobryum semiovatum (Brid.) Jaeg.

San Pedro, 1170 m., Jan. 20, 1934, *A. Alfaro* 68.

Although this species has been credited to Costa Rica this is the first local collection I have seen. Through the kindness of Mr. R. S. Williams I have been able to compare the local plants with Spruce's collection from Ecuador. They are apparently exactly alike. The percurrent or slightly excurrent costa and the relatively thin-walled upper leaf cells are characters which will

readily distinguish this species from most of its allies. It forms an interesting and suggestive link with *Bryum.*

Bryum insolitum Card. var. **brachycarpum** Bartr., var. nov.

Theca brevior, ovalis.

Tiribi, 1100 m., Oct. 28, 1933, *A. Alfaro* 21.

This unique species is a nice addition to the local list. Apart from the obviously shorter, more ovoid capsules these plants and those from Mexico seem to be identical.

BRYUM ANDICOLA Hook.

Syn.: *Bryum rosulicoma* Ren. & Card.

Cabeceras del Río Jorca, 1500 m., Oct. 22, 1933, *A. Alfaro;* Sarchi, 1980 m., Feb. 20, 1934, *A. Alfaro* 78.

There is no doubt in my mind but that this is one of the widely distributed types, similar to *Tortula fragilis* Tayl. and *Anacolia subsessilis* (Tayl.) Broth., ranging from the southwestern United States through Mexico, Central America, and western South America along the Cordilleran chain. *B. rosulicoma* Ren. & Card. and *B. rosulatum* C. M. are only two of what may prove to be an extensive list of synonyms.

BARTRAMIACEAE

PHILONOTIS UNCINATA (Schwaegr.) Brid.

La Fuente, 1200 m., Dec. 27, 1933, *A. Alfaro.*

The long setae and falcate leaves with long-excurrent costa seem to place this collection here rather than with *P. sphaericarpa.* Apparently not previously reported from Costa Rica.

ORTHOTRICHACEAE

MACROMITRIUM MEXICANUM Mitt.

Northwest slope of Cerro Carpintera, above La Unión de Tres Rios, 1320–1700 m., Prov. Cartago, Nov. 1, 1929, *C. W. Dodge & W. S. Thomas* 4789.

This appears to be the first species in the section Macrocoma to be recorded from Central America. The upper leaf cells are small, 5–7μ in diameter, as in *M. filiforme* (Hook. & Grev.), but the capsules are distinctly plicate in the upper half and the peristome teeth are not in pairs but are united in a low coarsely papillose ring extending a little above the rim, as in well-fruited plants of *M. mexicanum* collected by C. A. Purpus near Zacuapan, Vera Cruz. The agreement in peristome characters together with the crenulate leaf margins, especially in the lower half, suggests that the local collection may better be referred to *M. mexicanum.* Whether or not *M. mexicanum* is specifically distinct from *M. filiforme* is another question that may be deferred until better material of the latter is available for comparison.

Macromitrium mucronifolium (Hook. & Grev.) Schwaegr.

Banana River, 80 m., May 20, 1934, *F. Gutierrez.*

Although not listed in any of the previous papers relating to Costa Rican mosses, this species proves to be not uncommon. I had confused it with *M. apiculatum,* without having a clear understanding of the relative distinctions between these two species as illustrated on Schwaegrichen's Plate no. 170.

Macromitrium hirtellum Bartr.

Tilarán, 700 m., March 15, 1934, *A. Alfaro* 110.

This species is probably only a trivial form of *M. pentastichum* C. M. The uniform arrangement of the leaves around the stem, instead of in 5 rows, is not a very tangible character. The leaves are less widely spreading when moist, and more sharply pointed, but the structural details are nearly identical.

Micromitrium fragile (Mitt.) Jaeg.

Santa María, Guanacaste, 825 m., Feb. 9, 1934, *A. Alfaro.*

I have been thoroughly unsuccessful in finding any characters to separate this species from *M. Schlumbergeri* Schp., and believe that the latter name can safely be relegated to synonymy.

Schlotheimia Oerstediana C. M.

Guanacaste, 825 m., Dec. 25, 1933, *A. Alfaro* 50; Potreros near farmhouse at Hacienda Santa María and source of Río Liberia, Prov. Guanacaste, Jan. 21–24, 1930, *C. W. Dodge & W. S. Thomas* 6944, 6958, 6967; Roadside north of Tilarán, Prov. Guanacaste, Pacific slope, 500–690 m., Feb. 20, 1930, *C. W. Dodge & W. S. Thomas* 6579; Volcán de Barba, 1800 m., 1931, *Ruben Torres* 145.

These collections have not been referred here without considerable distrust. I have not succeeded in finding the narrowly lanceolate-acuminate inner perichaetial leaves described by Müller, but on the other hand the only inference I can draw from a careful comparison of a considerable series of specimens from southern United States, eastern Mexico, British Honduras, and Guatemala is that *S. Sullivantii* C. M., *S. Oerstediana* C. M., *S. Mohriana* C. M. and *S. Sartorii* C. M. are in reality only minor variants of one specific type. In this group the perichaetial leaves are only slightly longer than the stem leaves, longitudinally plicate, either smooth or transversely wrinkled in the upper half, and either mucronate or short-acuminate at the apex. As the differences are too slight and unstable to separate the forms clearly, I strongly suspect that *S. Sullivantii* C. M. may be used in an inclusive sense to cover the plants ranging from the southern United States to Costa Rica. A comparative study of the respective types is essential before any definite conclusion can be made.

CRYPHAEACEAE

ACROCRYPHAEA GARDNERI (Mitt.) Jaeg.

San Ildefonso, 1500 m., Jan. 21, 1934, *A. Alfaro;* Banana River, 80 m., May 17, 1934, *F. Gutierrez.*

The strongly reflexed leaf margins definitely associate these collections with *A. Gardneri* rather than *A. julacea* (Hornsch.). I know of no previous record of *A. Gardneri* from north of Colombia.

LEUCODONTACEAE

LEUCODONTOPSIS FLORIDANA (Aust.) E. G. Britt.

Laurel, Banana River, 100 m., May 2, 1934, *F. Gutierrez.*

This is the first collection of this species I have seen from Costa Rica, although it has been credited to the local flora.

METEORIACEAE

Squamidium crispipilum Bartr., sp. nov.

Figure 2.

Dioicum? Sat robustum, superne lutescenti-viride, intus fuscescens, nitidum. Caules elongati, penduli, inordinate et brevissime pinnatim ramosi.

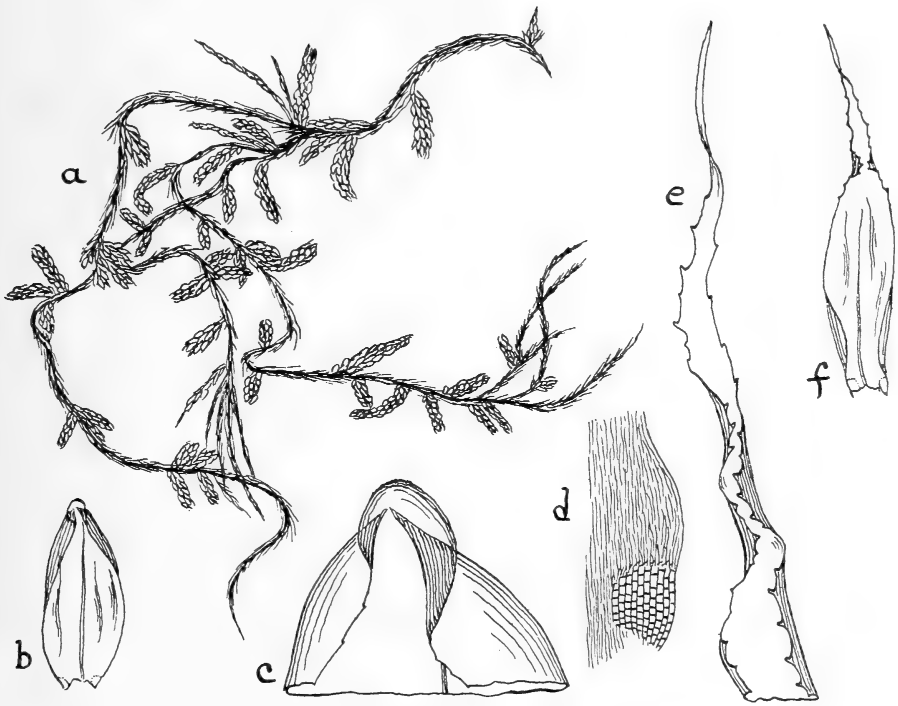

Fig. 2.—*Squamidium crispipilum* Bartr. a.—Part of plant ×1. b.—Branch leaf ×16. c.—Apex of branch leaf ×80. d.—Basal angle of branch leaf ×80. e.—Apex of stem leaf ×80. f.—Stem leaf ×16.

Folia dimorpha, caulina ovato-lanceolata, appressa, apice in acumen elongatum flexuosum canaliculatum argute serratum producta; nervo tenui, supra medium producto; cellulis linearibus, laevibus, ad angulos pluribus quadratis; ramulina ovalia, valde concava, apice galeata, nervo angusto sub apice evanido. Caetera ignota.

Dioicous? Rather robust plants growing in intricate masses, pale yellowish green at the tips, brown or blackish below, glossy. Stems long, flexuose, tangled, ending in slender flagellaceous tips; branches short, distant, blunt, sometimes in clusters. Stem leaves and branch leaves strongly differentiated. Stem leaves about 3.5 mm. long, erect or slightly spreading, concave, ovate-lanceolate, abruptly narrowed to a flexuose, crisped point, this slightly shorter than the leaf blade; margins erect, entire below, coarsely toothed from the base of the acumen to the apex, irregularly inflexed in the acumen; costa single, faint, ending about two-thirds up; leaf cells linear, 3–4μ wide by 12 to 16 times as long, shorter in several rows across the insertion with sinuose, pellucid lateral walls; alar cells numerous, sharply differentiated, short-rectangular, yellowish, in 8 or 9 rows, extending about half-way to the costa; branch leaves closely imbricated, strongly concave, indistinctly seriate, ovate, about 1.8–2 mm. long, contracted just below the rounded galeate apex; costa ending below the apex; margin erect, entire or very faintly denticulate above; leaf cells short and irregular at the extreme apex with pellucid, slightly pitted lateral walls, otherwise as in the stem leaves. Fruit unknown.

TYPE: Two miles southwest of Agua Caliente, 1050 m., April 1, 1928, H. E. Stork 1338.

The long, crispate hair points of the stem leaves are in bold contrast to the rounded, helmet-shaped leaves of the short lateral branches and clearly distinguish this species from any of its congeners. It is an unusually handsome moss. The rich, deep shades of brown in the tangled older parts make a fine background for the glossy stramineous tips of the younger growth.

METEORIOPSIS RECURVIFOLIA (Hornsch.) Broth.

Banana River, 80 m., May 17, 1934, *F. Gutierrez.*

An interesting extension in the range of this species, which has not been known previously north of Panama.

NECKERACEAE

NECKEROPSIS DISTICHA (Hedw.) Fleisch.

Siquirres, 60 m., Dec. 23, 1933, *A. Alfaro.*

Evidently not a common species in Costa Rica. This is the first local collection I have seen.

PINNATELLA MINUTA (Mitt.) Broth.

Banana River, 80 m., May 20, 1934, *F. Gutierrez.*

Only a few plants of this rare little moss were segregated from a mixture of other species, but the leaf characters are so obviously distinct from anything else in the region that its identity is almost certain. I doubt if it has ever been re-collected since the original gathering by Wright in Cuba.

HOOKERIACEAE

Daltonia tenuifolia Mitt.

Coronado, 1400 m., Dec. 17, 1933, *A. Alfaro;* Cabeceras del Río Jorco, 1500 m., Oct. 22, 1933, *A. Alfaro.*

Both of these collections are in good fruit and are interesting local records for a rare species.

Crossomitrium Oerstedianum C. M.

Banana River, 80 m., May 4, 1934, *F. Gutierrez.*

I have not seen the type, but the above collection agrees perfectly with Müller's description of this species. The very flat stems, closely appressed to the substratum with the leaves scarcely shrivelled when dry, give the plants the appearance of an hepatic. The lateral leaves are suborbicular, with a very short, blunt, oblique point, and show the characteristic paired teeth on the upper margins. The general aspect of the plants is very different from that of the group with arcuate, sharply pointed leaves, shrivelled when dry, which Brotherus groups in the section Phyllophila and to which the following species belongs. A critical study of the species of this strictly American genus is badly needed.

Crossomitrium Patrisiae (Brid.) C. M.

Laurel, Banana River, 100 m., May 2, 1934, *F. Gutierrez.*

Lepidopilum apiculatum Bartr., sp. nov.

Figure 3.

Dioicum, nitide lutescenti-viride. Caulis secondarius ascendens, complanatus, 2–3 cm. longus, circa 4 mm. latus. Folia sicca contorta, vix plicata, ovato-oblonga, abrupte breviterque apiculata, 2 mm. longa; marginibus anguste revolutis, superne planis minute denticulatis; nervis supra medium evanidis; cellulis superioribus rhombeis, marginalibus uniseriatis angustioribus, basilaribus longioribus; capsula in pedicello superne scabro 6–8 mm. longo erecta; operculo subulato-rostrato; calyptra ramentosa; peristomii dentibus margine sinuosis, strato ventrali angustissimo; sporae laeves, diam. 20–25μ.

Dioicous, densely tufted, glossy yellowish green plants. Antheridial plants mixed with the fruiting stems. Male buds 1.5 mm. long, axillary on the lower half of the stem. Secondary stems ascending, complanate, 2–3 cm. long, about 4 mm. wide with leaves. Leaves slightly contorted when dry, ovate-oblong, 2 mm. long, abruptly contracted to a short, half-twisted apiculus; margins plane and minutely denticulate above, narrowly revolute on one or both sides below; costae slightly divergent, ending above the middle; upper leaf cells oval and rhomboidal, 10–15μ wide, with firm, yellowish walls, one row at the margins linear, forming a very narrow inconspicuous border; basal cells more elongate, linear-rhomboidal. Seta 6–8 mm. long, flexuose, scabrous above, smooth below; capsule erect, ovoid-cylindrical; lid subulate-rostrate; calyptra sparingly ramentose; peristome teeth sinuose on the mar-

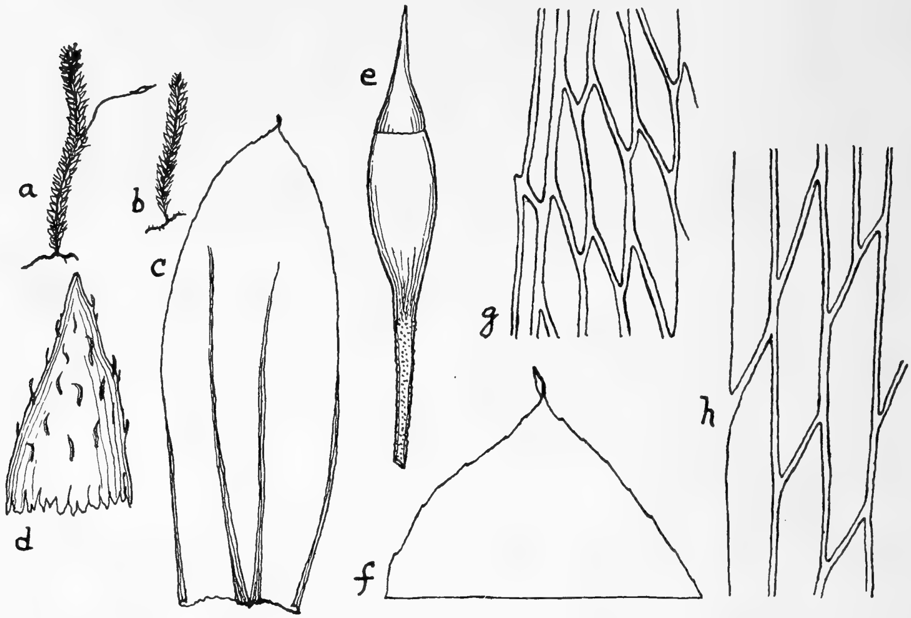

Fig. 3.—*Lepidopilum apiculatum* Bartr. a.—Fruiting plant ×1. b.—Antheridial plant ×1. c.—Lateral leaf ×35. d.—Calyptra ×12. e.—Capsule and upper part of seta ×12. f.—Tip of leaf ×80. g.—Upper leaf cells and margin ×400. h.—Basal leaf cells and margin ×400.

gins, the outer plates much wider than the inner layer; spores brownish, smooth. 20–25μ in diameter.

TYPE: Banana River 80 m., *F. Gutierrez.*

This species is probably nearest *L. cubense* Sull., but is clearly distinguished by the more broadly pointed leaves (which are abruptly contracted to a short, partly twisted apiculus), the longer costae extending well above the middle of the leaf, the minutely and distantly denticulate upper margins, and the narrower basal cells, which are not as lax as in *L. cubense.*

THUDIACEAE

THUIDIUM INVOLVENS (Hedw.) Mitt.

Banana River, 80 m., May 4, 1934, *F. Gutierrez.*

BRACHYTHECIACEAE

BRACHYTHECIUM STEREOPOMA (Spr.) Jaeg.

Coronado, 1400 m., Dec. 17, 1933, *A. Alfaro;* Alajuelita, 1600 m., Dec. 18, 1933, *A. Alfaro* 33; San Ildefonso, 1500 m., Jan. 21, 1934, *A. Alfaro;* Moravia, 1300 m., Feb. 11, 1934, *A. Alfaro.*

The authors indicate that *B. costaricense* Ren. & Card. may be easily distinguished from *B. stereopoma* by the leaves strongly excavate at the base on each side of the nerve and by the more robust branches. These differences

are not at all well defined when a broad series of specimens is compared, and I am unable to find any stable characters by means of which the two species may be clearly separated. Like all widely distributed species *B. stereopoma* is variable within reasonable limits, but I doubt if these varations can be correlated with any distinct specific concepts.

ERIODON RADICALIS Spruce

Asserí, 1400 m., Feb. 4, 1934, *A. Alfaro.*

This is an unusually interesting collection and, so far as I know, the first time the species has been discovered since Spruce's original collection in Ecuador. The Costa Rican plants are identical with those from Ecuador and add a new genus to the North American moss flora.

ENTODONTACEAE

ERYTHRODONTIUM SQUARROSUM (C. M.) Par.

Guadalupe, 1200 m., Dec. 2, 1933, *A. Alfaro.*

CAMPYLODONTIUM ONUSTUM (Hpe.) Jaeg.

Pejivalle, 600 m., Sept. 30, 1933, *A. Alfaro.*

The above collection is identical with authentic specimens from Colombia and Venezuela. Apparently it is the first record of the species in North America.

ENTODON BEYRICHII (Schwaegr.) C. M.

Asserí, 1400 m., Feb. 4, 1934, *A. Alfaro;* Alajuelita, 1380 m., Jan. 20, 1934, *A. Alfaro;* Jorco, 1200 m., Oct. 21, 1933, *A. Alfaro;* Tiribí, 1100 m., Oct. 28, 1933, *A. Alfaro.*

This species has a wider distribution than Brotherus indicates. It has been collected in Jamaica and Haiti, and apparently the specimens from Costa Rica recorded in my previous papers under the names of *E. erythropus* Mitt. and *E. Bernoullii* C. M. are all referable here. There is nothing in the description of *E. Bernoullii* C. M. to distinguish it from *E. Beyrichii* and I suspect that it should be reduced to a synonym of this species.

PLAGIOTHECIACEAE

STEREOPHYLLUM RADICULOSUM (Hook.) Mitt.

Santa María, Prov. Guanacaste, 825 m., Dec. 25, 1933, *A. Alfaro.*

Although this species does not seem to have been reported from Costa Rica before, it is not an unexpected addition to the local flora. The leaf cells are often clearly unipapillate on the back, rather than consistently smooth as indicated by Brotherus.

SEMATOPHYLLACEAE

PTEROGONIDIUM PULCHELLUM (Hook.) C. M.

Banana River, 80 m., May 4, 1934, *F. Gutierrez.*

The only local record that I know of for this delicate little species.

HYPNACEAE

Isopterygium subtrichopelma Ren. & Card.

La Fuente, 1200 m., Dec. 8, 1933, *A. Alfaro;* Cabaceras del Río Jorco, 1500 m., Oct. 22, 1933, *A. Alfaro.*

It seems very doubtful if this species is anything more than one of the variants of *I. tenerum* (Sw.) Mitt.

Taxiphyllum planissimum (Mitt.) Broth.

Asserí, 1400 m., Feb. 4, 1934, *A. Alfaro.*

Another interesting but not unexpected addition to the local list, the species having been known previously from Mexico, the West Indies, and Ecuador.

Vesicularia crassicaulis (Mitt.) Broth.

Banana River, 80 m., May 20, 1934, *F. Gutierrez.*

The slenderly acuminate, falcate-secund leaves clearly separate these plants from both *V. amphibola* and *V. vesiculare.* It extends the range of the species considerably to the southward and is a fine addition to the local flora.

BOTANY.—*Two new grasses, one from Tennessee, one from Argentina*[1]

A. S. Hitchcock, Bureau of Plant Industry.

Recently Mr. Stanley A. Cain, of the Indiana Academy of Sciences, Bloomington, Indiana, sent to me a specimen of an apparently new grass which he had collected in the mountains of eastern Tennessee. This proved to be a new species of *Calamagrostis,* allied to *C. porteri* A. Gray and *C. perplexa* Scribn.

About the same time I received from Dr. F. C. Hoehne, of the Instituto Biologico, São Paulo, Brazil, a dwarf grass collected by Dr. A. Burkart in the high mountains of the Province of Tucumán, Argentina. This also proved to be undescribed. It is one of the smallest species of the genus *Catabrosa,* of which there are a few in southern South America. The genus is represented in the United States and northern Eurasia by *C. aquatica* (L.) Beauv., a relatively large widely distributed species, found in mountain meadows, bogs, and wet places.

Calamagrostis cainii Hitchc., sp. nov.

Perennis, dense caespitosa, rhizomatibus brevibus; culmi graciles, erecti, infra paniculam scabri, 30–40 cm. alti; vaginae glabrae; ligula 1–2 mm. longa; laminae planae, longe acuminatae, infra glabrae, supra scabrae, 20–35 cm. longae, 1–2 mm. latae, suprema 5–10 cm. longa; panicula pauciflora, pat-

[1] Received September 21, 1934.

ula, pallida, 6–10 cm. longa, axi scabro, ramis 1–2 cm. longis; glumae angustae, acuminatae, 5–6 mm. longae; lemma acuminatum, pilis calli 1–2 mm. longis, infra medium aristatum, arista medio geniculata, inferne torta, glumas paullum excedente; processus rachillae brevis, villis 1–2 mm. longis.

Perennial, densely cespitose, with short rhizomes; culms slender, erect, scabrous below panicle, 30–40 cm. tall; sheaths glabrous; ligule of culm leaves thin, rounded or obtuse, finely dentate, becoming lacerate, 1–2 mm. long; blades erect, flat, more or less involute toward the finely attenuate tip, glabrous beneath, scaberulous on the upper surface, narrowed toward base, the basal ones as much as 35 cm. long, 1–2 mm. wide, the uppermost culm blade 5–10 cm. long, about 1 mm. wide; panicle pale or whitish, loose, 6–10 cm. long, the axis scabrous, the branches ascending or somewhat spreading, verticillate, scabrous, 1–2 cm. long, bearing 1–few spikelets, the whorls 7–15 mm. apart, the pedicels scabrous-pubescent; glumes narrow, nearly equal, acuminate or slightly aristate, glabrous except the scabrous upper half of the keels, 5–6 mm. long, the first 1-nerved, the second 3-nerved; lemma narrow, acuminate, 5-nerved, glabrous below, minutely scaberulous near the finely toothed summit, the callus hairs about 1 mm. long, the awn about 1 mm. from base, somewhat geniculate, twisted below, the tip bent to one side and somewhat exceeding the glumes; palea a little shorter than the lemma; prolongation of the rachilla very short but the hairs 1–2 mm. long.

Type in the U. S. National Herbarium, no. 1,611,706, collected on the shrubby summit of Mt. LeConte, Tennessee, alt. about 2000 meters, August 10, 1929, by *Stanley A. Cain* (no. 48). Later Mr. Cain sent specimens (no. 1016) from the same locality, with the statement that the species grew abundantly on cliffs in spruce-fir formation.

Catabrosa Burkartii Hitchc., sp. nov.

Perennis, pusilla; culmi caespitosi, erecti, 1–3 cm. alti; vaginae glabrae; ligula 1–2 mm. longa; laminae planae vel plerumque complicatae, glabrae, graciles, 5–20 mm. longae; panicula angusta, pauciflora, 5–8 mm. longa; spiculae 3–4 mm. longae, 2-flores, glabrae; lemmata oblonga, obtusa, circa 3 mm. longa.

Dwarf cespitose perennial; culms glabrous, erect, 1–3 cm. tall; sheaths glabrous, striate-nerved, rather loose, the uppermost somewhat inflated; ligule thin, 1–2 mm. long; blades mostly folded, rather firm, somewhat falcate, glabrous, 5–20 mm. long, about 0.3 mm. thick as folded, the rounded or boat-shaped tip cartilaginous, the lower blades sometimes flat and 1 mm. wide; panicle narrow, 5–8 mm. long bearing a few yellowish short-pediceled spikelets, the branches slightly scabrous on the angles; spikelets 3–4 mm. long, 2-flowered; glumes about equal, broad, rather obscurely nerved, glabrous, rounded at the somewhat erose tip, 2.5–3 mm. long; lemmas glabrous, the first oblong, obtuse, a little more than 3 mm. long, the upper part with a yellowish zone below the rounded minutely erose summit, the palea narrow, shorter than the lemma; second lemma similar to the first but slightly shorter, the summit about as high as that of the first, the internode of the rachilla between the florets being very short.

Type in the U. S. National Herbarium, no. 1,539,407, collected on the summit of Calchaquíes, Dept. Tafí (Prov. Tucumán), Argentina, alt. 4200 meters, January 30, 1933, by *A. Burkart* (no. 5348). Part of the type in the herbarium of the Instituto Biologico, São Paulo, Brazil.

PALEOBOTANY.—*Three additions to the Pleistocene flora of Tennessee.*[1] EDWARD W. BERRY, The Johns Hopkins University.

In the fall of 1931 Walter F. Pond, State Geologist of Tennessee, sent me some samples of impure lignite encountered in a well 5 miles east of Dayton in that state. The country rock is Knox dolomite and it seems probable that the silty lignite was formed in a sink in the dolomite. The age of the lignitic deposit is a matter of considerable interest. Fortunately I am now able to determine the age with considerable certainty. On one specimen of the lignitic clay there is an excellent impression of two-thirds of a leaf which after extensive comparison with recent material I am convinced is a leaf of the existing button-bush, honey-ball, or globe-flower, *Cephalanthus occidentalis* Linné, a shrub of swamps and low ground, ranging from eastern Canada to Mexico, and common in the Tennessee region. This means that the lignite is Pleistocene in age.

Interestingly enough *Cephalanthus occidentalis* has been reported by Auer (1930, p. 31) from the peat of Marsh Hill and Welland in southeastern Canada. Other than this the genus has never been reported as a fossil, although the 6 existing species are found in eastern Asia, North and South America, and West Africa, and this distribution is fair evidence that the genus has a Tertiary history.

In March, 1933, I received from E. L. Spain, Jr., of Vanderbilt University, a small amount of clay underlying a peaty layer in terrace deposits on a tributary of the Cumberland River, central Stewart County.

This clay was silty and broke down readily in water, and was found to contain characteristic fragments of *Quercus alba* Linné and *Quercus imbricaria* Michaux.

Quercus alba has been recorded from Ontario Interglacial deposits,[2] from the Port Kennedy cave in Pennsylvania,[3] from the Chowan formation of North Carolina,[4] from Buena Vista, Virginia,[5] from post Pleistocene deposits in Massachusetts,[6] and is probably represented in the Sunderland formation of Maryland by what Hollick called *Quercus pseudoalba.*[7] It ranges in the recent flora from Maine, Ontario and Minnesota to Florida and Texas.

[1] Received August 20, 1934.
[2] PENHALLOW, D. P. Amer. Nat. **41**: 448. 1907.
[3] MERCER, H. C. Jour. Acad. Nat. Sci. Phila. **11**: 281. 1899.
[4] BERRY, E. W. Jour. Geol. **15**: 342. 1907.
[5] BERRY, E. W. Am. Jour. Sci. **34**: 221. 1912.
[6] EMERSON, B. K. U. S. Geol. Surv. Bull. **597**: 148. 1917.
[7] HOLLICK, A. Md. Geol. Surv. Pliocene & Pleistocene, p. 227, *pl. 70, fig. 2, pl. 71, figs. 1–6.* 1906.

Quercus imbricaria has been recorded from Bridgeton, N. J. by Lesquereux[8] from beds which I consider as probably Pleistocene in age, although they have usually been considered somewhat older. In the recent flora it ranges from Pennsylvania to Michigan and Arkansas, Georgia and Tennessee.

[8] LESQUEREUX, L. U. S. Nat. Mus. Proc. **10**: 39. 1887.

ZOOLOGY.—*New experimental hosts for* Brachylaemus virginiana *(Dickerson) Krull.*[1] WENDELL H. KRULL, Bureau of Animal Industry.

The white rat, dog, cat, and chicken have been infected experimentally with *Brachylaemus virginiana,* a fluke normally parasitic in the opossum, *Didelphis virginiana,* and mature flukes have been recovered from these hosts. Eggs of *B. virginiana* collected from the feces of one of the experimentally infected dogs were used to infect the normal first intermediate host, *Polygyra thyroides.* Consequently, it is assumed that some, at least, of the new hosts are potentially capable of disseminating the parasite in regions where the opossum and its snail host are found.

The metacercariae of *B. virginiana* used in the following infection experiments were obtained from laboratory raised and infected snails, *P. thyroides;* an extensive account of these infection experiments is being given by the writer in a paper now in press. Every snail used in the subsequent experiment contained hundreds of metacercariae, all of which were 7 months old.

Two puppies, litter mates, were used in the present experiment. A puppy 5 weeks old was given approximately 200 metacercariae, and when it was killed, 7 days later, 111 mature specimens of *Brachylaemus virginiana,* 2.05 to 2.60 mm. long when stained and mounted, were recovered from the intestine. The uterus in each of these flukes was extensive and filled with apparently normal, brown colored eggs. The second puppy, when 6 weeks old, was given approximately 400 metacercariae. Eggs were recovered in the feces of the dog 12 days after the metacercariae were administered; eggs were quite common in the feces a day later, abundant 5 days after that, and fewer in number 9 days later, or 27 days after the dog was infected. Since there was an apparent decrease in the number of eggs it was suspected that the infection was being lost; however, when the animal was killed 349 flukes were recovered. These were large and equal in size to any

[1] Received August 24, 1934.

recovered from an opossum. The trematodes were localized in a comparatively small area in the posterior part of the small intestine. They were very conspicuous because of the numerous dark colored eggs in the extensive uterus which occupies the greater part of the intercecal field. On 3 previous occasions metacercariae of *B. virginiana* have been given to adult dogs and no infections ever developed, and, while not enough dogs were used for the results to be significant, the experiment indicates that adult dogs apparently are not easily infected.

Eggs of *Brachylaemus virginiana* from the feces of the second puppy in the present experiment were used to infect the normal first intermediate host, *Polygyra thyroides*. Four snails were subjected to infection, and 2 of them became infested.

Two kittens, litter mates, were used in infection experiments. A suckling kitten, 2 weeks old, was given approximately 100 metacercariae and when it was examined postmortem, 7 days later, 74 mature flukes, 1.95 to 2.25 mm. long when stained and mounted, were recovered. The uterus in each fluke was extensive and filled with normal brown colored eggs. A second kitten, 3 weeks old, was given about 200 metacercariae, and eggs of the fluke appeared in the feces 14 days later. Eggs were common in the feces of the host 3 days later, and fewer after 10 more days, or 27 days subsequent to the time the animal was subjected to infection. The kitten was weaned while it was infested and when examined postmortem, 27 days after receiving the metacercariae, 50 adult flukes were recovered; they were in the posterior part of the small intestine, as in the case of the dog.

Two chicks were used in infection experiments; these were less than 24 hours old when subjected to infection. One chick was given 50 metacercariae, and when destroyed, 2 days later, 5 immature flukes were recovered from the posterior part of the small intestine. These flukes had grown considerably and had attained adult shape. The other chick received 75 metacercariae and 5 days later 6 mature flukes, 1.95 to 2.35 mm. long when stained and mounted, were recovered postmortem from the intestine. All flukes had normal colored eggs in the terminal part of the descending branch of the uterus.

On previous occasions attempts to infect 4 chickens with *B. virginiana* had been unsuccessful. These chickens were fully feathered at the time they were subjected to infection. Since the cause of the failure to infect these chickens is not known, and since the diet may have had something to do with the negative results, it should be stated that these chickens were fed on grain, while the chicks which

became infested in the present experiment were given bits of raw beef.

A small rat, which had just been weaned, was given 75 metacercariae, and when examined, 3 days later, 2 mature flukes, each containing a couple of eggs were recovered from the small intestine. A second rat, fully grown, received approximately 100 metacercariae, and when killed 4 days later, 5 mature flukes were recovered postmortem from the small intestine. The flukes from this rat contained numerous normally colored eggs.

Previously it was found by the writer that *Brachylaemus virginiana* would live in the white rat only 3 days. In view of the small number of parasites recovered from the rats in the present experiment, in spite of the comparatively large numbers of metacercariae which were administered, it is suspected that previous failure to obtain adult flukes in white rats resulted from using too few metacercariae in attempts to infect them.

SUMMARY AND CONCLUSIONS

The experiment shows that the dog, cat, chicken, and white rat may serve as definitive hosts of *Brachylaemus virginiana* of which the opossum is the natural definitive host. It is apparent from the data presented that there may be a difference in the rate of maturity and growth after maturity of the flukes in the different hosts. More data, however, are necessary to verify this point. A comparison of flukes of the same age from a kitten and a puppy, however, showed a striking difference in size, the flukes in the puppy being larger than those in the kitten. Young dogs and cats become infected easily, and practically all of the metacercariae establish themselves, which fact is not apparent in the case of chickens and rats.

The results of these experiments suggest that some of the described species in this genus, which are morphologically similar, are not good species, but have been recognized as valid largely because of host relationship. It is also apparent that, since *B. virginiana* has been established in several hosts, it may be a suitable trematode with which experiments relative to age resistance, longevity, and the relation of the fluke to food habits of the host may be undertaken.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

510TH MEETING

The 510th meeting of the Society was held in the Assembly Hall of the Cosmos Club, Jan. 10, 1934, President H. G. FERGUSON presiding.

Program: LAWRENCE MARTIN: *A standard map of the maxima of Pleistocene glaciation in North America.* Discussed by Messrs. MATTHES and CAPPS.

W. G. HOYT: *Forests and stream flow.*—Following the deforestation (removal of trees by cutting) of a high mountain area in the vicinity of Wagon Wheel Gap, Colorado, the average annual run-off of the deforested area was increased 15 percent, the maximum peak discharge was increased 46 percent, and the summer and fall run-off was increased 12 percent.

Following the denudation (destruction by fire of all ground cover and tree litter) of a coastal mountain drainage basin in southern California, the average annual run-off of a denuded area was increased 29 percent. The maximum peak discharge of the first four floods following denudation was increased about 1,700 percent, and the summer and fall run-off was increased 475 percent.

The increase in the annual run-off was distributed rather uniformly throughout the year, 52 percent of the increase from both areas occurring during periods of non-flood run-off and 48 percent during periods of flood run-off.

In the Colorado area there was practically no evidence of erosion after deforestation and this was to be expected because there was little direct surface run-off either before or after deforestation. In the southern California area complete denudation increased erosion as a direct result of increased surface run-off and deposition of eroded material and ash carried by the stream the first year after the fire was materially injurious to agricultural lands and transportation rights of way.

Conclusive evidence showed that on these two areas (1) forests and brush cover substantially lower stream flow at practically all seasons and all stages, including flood, minimum and total flow; (2) forests and brush cover substantially lessen erosion where readily eroded material is available, and (3) new vegetative growth exercises an effect similar to the original cover in retarding erosion, but without so detrimental an effect on annual run-off and summer low-water flow.

In watershed protection studies it is therefore necessary to determine the type of cover which will best protect the soil, minimize the water losses and provide for the most economical use of the watershed area and of the water yield. The cover may be forests or other plant species depending on the soil, topography, climate, and nature and amount of water supply requirements of the dependent region. (*Author's abstract.*) Discussed by Messrs. FERGUSON, BRIDGE, COOKE, MENDENHALL, TRASK, BRADLEY, SPENCER, RUBEY, MERTIE, and THOMPSON.

E. T. MCKNIGHT: *Origin of zinc and lead deposits of northern Arkansas.* Discussed by Messrs. FERGUSON, TRASK, BRIDGE, GOLDMAN, SPENCER, BRADLEY, HENBEST, and RUBEY.

511TH MEETING

The 511th meeting of the Society was held in the Assembly Hall of the Cosmos Club, Jan. 24, 1934, President H. G. FERGUSON presiding.

Informal communication. R. W. BROWN exhibited a specimen from Peru, described by F. H. Knowlton as *Zea antiqua*, a supposed new species of fossil corn. Restudy of the specimen by means of thin sections showed it to be baked pottery.

D. F. HEWETT called attention to the analyses of the wall rocks of Virginia caves listed on page 143 of W. M. McGill's *Caverns of Virginia.* Of samples from 13 developed caves, 6 contain less than 1 percent $MgCO_3$; 3 contain between 1 and 3 percent; 3 contain between 5 and 14 percent; and one contains 30 percent of $MgCO_3$. The predominant non-dolomitic character of the cave-forming rocks lends strength to the hypothesis that the dolomitic zinc-bearing breccias of the Appalachians are of tectonic origin. Discussed by Messrs. KEITH, BUTTS, and BEVAN.

M. I. GOLDMAN reviewed a recent monograph on fossil Protozoa by OTTO WETZEL entitled *Die in organischer Substanz erhaltenen Mikrofossilien des Baltischen Kreide-Feuersteins mit einem sedimentpetrographischen und stratigraphischen Anhang* which appeared in 1933 as vol. 78, part A of Paleontographica. He showed slides of two of the plates illustrating flagellate and radiolarian-like organisms. GOLDMAN also called attention to an early paper by M. C. WHITE, appearing in the American Journal of Science in 1862, which described similar forms. Discussed by Messrs. RESSER and HESS.

Program: C. LEWIS GAZIN: *A marsupial from the Florissant beds of Colorado.*—In 1929 the U. S. National Museum purchased from G. F. Sternberg fossil remains of a mammal collected by him in the Florissant beds of Colorado. These beds, renowned for their fossil flora and insect fauna, have heretofore produced no identifiable mammalian remains, although a few birds and fish have been described. The didelphid mammal discovered in the Florissant beds apparently represents the extinct genus *Peratherium*, a small marsupial resembling the murine opossum *Marmosa* now living in southern Mexico, Central and South America. *Peratherium* is known in the Tertiary of North America in several stages from the Fort Union Paleocene to the middle John Day horizon of upper Oligocene or lower Miocene age, but has never been recorded from later beds in this country. Of the various forms described the Florissant specimen seems to correspond most closely to the species *Peratherium huntii* from the Cedar Creek beds of Oligocene age in northeastern Colorado.

On the basis of the known distribution of *Peratherium* it is suggested that the Florissant beds may be of earlier age than the upper Miocene stage currently assigned to them. From the similarity between the Florissant *Peratherium* and *P. huntii* it is further suggested, but not certainly demonstrated, that the age is Oligocene. (*Author's abstract.*) Discussed by Mr. LOVERING.

C. R. LONGWELL: *Some structural problems in central Connecticut and Massachusetts.* Discussed by Miss JONAS and Messrs. STOSE, GOLDMAN, G. O. SMITH, MENDENHALL, LOVERING, and BOWIE.

512TH MEETING

The 512th meeting of the Society was held in the Assembly Hall of the Cosmos Club, Feb. 14, 1934, President H. G. FERGUSON presiding.

Informal communications: T. A. HENDRICKS exhibited and discussed

specimens of rolled siltstone from Pennsylvanian strata of the Oklahoma Coal fields. Discussed by G. A. Cooper.

R. B. Stewart reviewed critically Bucher's *Deformation of the Earth's Crust.* Discussed by W. W. Rubey.

Program: L. K. Wenzel: *Thiem's method of determining permeability and pumping-test method of determining specific yield of water-bearing materials.*—A pumping test was made in the summer of 1931 near Grand Island, Nebraska, to determine the usefulness of Thiem's method for determining permeability and the pumping-test method for determining specific yield. An irrigation well was pumped continuously for 48 hours during which time the drawdown of the water table was measured in 81 observation wells spaced from 2 to 1,200 feet from the pumped well. Data were also obtained on the discharge of the pumped well, the thickness of the water-bearing formation, and the normal slope of the water table.

It was found that the coefficients of permeability computed by Thiem's formula, instead of being constant, varied through a wide range because the conditions observed in the field did not correspond to the theoretical conditions assumed in the development of the formula. However, a constant and accurate value of the permeability of the material was finally obtained by substituting in Thiem's formula only the drawdown of the water table where the cone of depression had reached approximate equilibrium in form—from about 50 to 200 feet from the pumped well. This procedure was adopted because Thiem's formula is based on the assumption that the cone of depression has attained an equilibrium condition. Certain other modifications in the use of the method were made which resulted in a more accurate determination of the true permeability. It is now thought that this method is the best method for determining permeability.

The specific yield of the water-bearing material was obtained by applying Darcy's law to the flow of water through concentric cylindrical cross-sections of material around the pumped well. The values of specific yield increased with the period of pumping because all of the water did not immediately drain out of the unwatered material. A final value for the specific yield was obtained by plotting the values of specific yield against the period of pumping and by extending the curve drawn through these points. The final value compared closely with the specific yield obtained by laboratory analyses of samples of the material. (*Author's abstract.*) Discussed by Messrs. Thompson, Meinzer, Ferguson, and Leggette.

T. B. Nolan: *The geyser area near Beowawe, Nevada* (by title).

E. N. Goddard: *The relation of Tertiary intrusives to ore deposits of Jamestown, Colorado.*—In the Jamestown mining district, in the Colorado Front Range 35 miles northwest of Denver, there are two Tertiary (Eocene?) stocks and numerous dikes that seem to have a genetic relation to the ore deposits. These Tertiary "porphyries" have been intruded into a pre-Cambrian complex of schist and granite. The earliest is a large approximately rectangular stock (about $1\frac{1}{2}$ by $2\frac{1}{2}$ miles) of hornblende granodiorite, having a N. 12° E. trend. On its north border is a small stock (about three quarters of a mile in diameter) of quartz monzonite porphyry, and to the east of these stocks are northeast dikes of quartz monzonite, bostonite, and alaskite porphyry. These porphyries were intruded after the greater part of the regional deformation of the Laramide revolution had taken place.

In the district there are two systems of post-porphyry fault fissures that are occupied by the ore deposits; a northwest system (in general, the earlier)

and a northeast system. The northwest system comprises breccia zones and veins that are confined to a narrow belt on the southwest border of the quartz monzonite stock. The northeast system consists of N. 60–70° E. fissures, and is largely confined to the east sides of the stocks.

The ore deposits show a rough zonal arrangement around the quartz monzonite stock. Fluorspar, the earliest of the ore deposits, occurs in the northwest system of fractures and breccia zones close to the southwest border of the stock. Lead-silver deposits occur in pipes or veins in or near fluorspar deposits in a small area of about a half square mile on the west side of the stock. Pyritic gold veins occupy the northeast fault fissures 1 to 2 miles east of the stock. Gold telluride veins occupy northeast fault fissures 2 to $2\frac{1}{2}$ miles east of the stock, and a few $\frac{1}{2}$ to 1 mile west of the stock. This description shows an unsymmetrical and rather irregular arrangement of the ores around the quartz monzonite stock.

In an attempt to account for this irregular distribution of the ores, the Cloos' method of mapping the internal structures of igneous masses was applied to the porphyry bodies. In the large granodiorite stock the platy and linear structures indicate a roughly elliptical cylindrical mass which pitches 60 to 70° south-southwest. During its emplacement, it probably moved upward in a N. 15° E. direction at an angle of about 65°. The magma apparently came up along a fracture-like opening and widened its channel by pushing outward in a S. 75° E. direction against a weak zone of granite and schist. In response to this force, the rocks tended to break at angles of slightly less than 45° to the direction of force. Both N. 65° E. and N. 35° W. fractures were actually formed, but since the schistosity trends N. 65° E., strong persistent fractures were developed in this direction, and short weak ones in the N. 35° W. direction. The strong northeast fractures were first filled with porphyry dikes, and later by successively younger ore deposits.

In the quartz monzonite stock the platy and linear structures indicate a somewhat funnel-shaped mass which pitches southwest at about 55°. Apparently, during emplacement, the magma moved upward at this angle in a northeast direction, and came up along the underside of the granodiorite mass. It seems probable that the northwest belt of breccia zones and fractures was formed as a result of combined upward force and drag in a northeast direction, developed during emplacement of the quartz monzonite stock.

Thus in the Jamestown district, and perhaps in other districts, the mapping of internal structures of intrusive masses related to ore deposits affords a valuable aid in attempting to solve the structural problems of ore distribution. (*Author's abstract.*) Discussed by Messrs. LOUGHLIN, FERGUSON, and LOVERING.

513TH MEETING

The 513th meeting of the Society was held in the Assembly Hall of the Cosmos Club, Feb. 28, 1934, President H. G. FERGUSON presiding.

Program: E. T. ALLEN: *Types of rock leaching by thermal waters in Yellowstone Park.* Discussed by Messrs. HESS, R. C. WELLS, GOLDMAN and TRASK.

A. I. JONAS: *Hypersthene granodiorite in Virginia; its change to unakite and its age.*—Hypersthene granodiorite occurs in three main belts in the western part of the Catoctin-Blue Ridge anticlinorium of Virginia. It is a grayish green rock made up of potash and plagioclase, feldspar, pyroxene, and quartz. Along the western side of the granodiorite areas it contains a varying

amount of pink feldspar, secondary epidote, and quartz. It has been called unakite where pink feldspar, epidote, and quartz are the chief constituents. Microscopic study shows the granodiorite has been subjected to a series of hydrothermal changes. It is thought that these hydrothermal changes were produced by action of residual magma extracts upon consolidated portions of the granodiorite. The changes include addition of silica to form quartz, of sodic solutions to form myrmekite and chessboard albite, and in part of the area, of the lime-iron silicate epidote and of ferric iron to form fine hematite flakes that color the feldspars pink. Unakite has been produced from the grayish green granodiorite by replacement of hypersthene and other constituents by epidote, change of gray-green feldspars to pink, and introduction of quartz filled with fine rutile needles, which impart blue color to the quartz.

In southwest Virginia the green schistose facies of the granodiorite with pink feldspars has been called the Grayson granite. It is bounded on the southeast by the Independence overthrust which has carried Lynchburg micagneiss northwestward over Grayson granite and infolded Unicoi quartzite. The Great Gossan lead occurs along this zone of thrust faulting.

The granodiorite is believed on stratigraphic grounds to be pre-Cambrian in age and older than the metabasalt flows which cap it in northern Virginia. In Nelson and Amherst counties the granodiorite contains allanite-bearing pegmatite. Analysis of allanite from the Friar, a granodiorite peak in northern Amherst County, gives a lead ratio that indicates an age of about 900 million years for the allanite, and it is probably middle pre-Cambrian in age. (*Author's abstract.*) Discussed by Miss BASCOM, and Messrs. FERGUSON, STOSE, and LOVERING.

J. S. WILLIAMS: *Correlation of the Louisiana limestone with beds at Kinderhook, Illinois, and Burlington, Iowa.*—The Louisiana limestone (lower Mississippian) is one of the formations of the Kinderhook group. Its type locality is in northeastern Missouri, and its outcrops are limited to this part of Missouri and to a small area in western Illinois. It occurs only in one of the four Kinderhookian provinces of Missouri, the northeastern province. The formations of this province, including two which may properly belong below the Kinderhook, are, in ascending order, the Grassy Creek shale, the Saverton shale, the Louisiana limestone, the Hannibal shale, and the Chouteau limestone. These formations are best exposed along the Mississippi River from central Lincoln County, Missouri, to central Marion County, Missouri. Most of them are, however, also recognizable in Illinois in counties east of and adjacent to the southern part of the Missouri outcrop area.

The type region for the Kinderhook group is in Illinois, near the town of Kinderhook, about 12 miles east of Hannibal, Missouri. Hannibal is in Marion County, Missouri, and is close to the northern edge of the northeastern Missouri Kinderhookian province. The best known and most fossiliferous Kinderhookian section in this region is, however, at Burlington, Iowa, about 80 miles north of Hannibal. It is not difficult to identify by lithology the beds at Kinderhook in the section at Burlington. It is, however, despite the proximity of these two sections to the northeastern Missouri province, impossible to correlate the Missouri beds with the beds at Kinderhook and Burlington by the ordinary physical means of correlation, a fact that has been stressed by nearly every investigator who has studied the sections. Direct tracing is impossible, well logs and other subsurface data are inadequate, and matching of lithologic units and successions, or of uncon-

formities does not give decisive results. Microscopic and chemical methods of physical correlation have not been attempted, but because of differences in the lithologies of the beds, they appear to promise little.

Faunal data are, when critically examined, of but little more correlative value than known physical data. This is especially true of correlations between the Missouri beds and beds at Burlington or Kinderhook. It is, however, less true in the correlation of the only really fossiliferous bed at Kinderhook with the Burlington section. Most faunal correlations that have been made appear not to have considered some of the unusual conditions that obtain in this area, or to have been actually based more on physical than on faunal data. Among the unusual conditions likely to affect the reliability of faunal correlations are the following: (1) common species are too few for definite conclusions (a change of an identification or two or of a stratigraphic range or two would very materially affect correlations); (2) work under way by Dr. G. H. GIRTY and the writer indicates that published ranges of several species are too narrow; (3) the total number of species (the fauna) varies greatly as between different beds in the sections; (4) the extent of a clearly demonstrated facies influence is not known; (5) the beds are thin and facies changes were rather frequent; (6) the lack of recent descriptive work and the composite origin of some of the fossil lists affects the reliability of the lists; and (7) differences in generic and specific concepts between various contributors to the available lists and changes in the application of these concepts by individuals from class to class and from time to time over a rather long period of years, render the use of lists on correlation uncertain.

The writer's study of the Louisiana fauna together with his observations on a considerable number of species from the Burlington section, and from nearly every one of the Kinderhookian beds of Missouri, influences him to agree with those parts of recent correlations that place beds 2 (of Weller) at Burlington and at Kinderhook stratigraphically above the Louisiana limestone. This conclusion is supported by the matching of species, the appearance of "new" genera and "new" species, and the relative percentages of species in the various beds. The writer cannot agree, however, that there are adequate faunal data for determining the age relation of the Louisiana limestone to beds 1 at either Kinderhook or Burlington or that there are adequate data for correlating strictly on a faunal basis, beds 2, 3, and 4 at Burlington or beds 2 or 3 at Kinderhook with any one bed in the Missouri section.

Most of the faunas appear to be local ones. The Louisiana fauna is certainly not represented as a fauna in either the Burlington or Kinderhook sections. The Louisiana limestone may have been eroded from the Burlington or Kinderhook regions or these areas may have been the sites of nondeposition or of deposition of different types of sediment during Louisiana time. A contemporaneous restudy of the faunas of all three sections is needed to make correlations more certain or to show definitely that under conditions such as obtain here, thin beds cannot be individually correlated. (*Author's abstract.*) Discussed by Messrs. BUTTS and STANTON.

514TH MEETING

The 514th meeting of the Society was held in the Assembly Hall of the Cosmos Club, Mar. 14, 1934, President H. G. FERGUSON presiding.

Informal communications: Mr. SPENCER exhibited and discussed a polished pebble from Gainesville, near Bull Run, Virginia.

Program: P. D. TRASK and H. F. HAMMAR: *Preliminary study of source*

beds in the Mesozoic rocks on the west side of the Sacramento Valley.—This paper presents results arising from an investigation of source beds of petroleum, sponsored both by the United States Geological Survey and the American Petroleum Institute. The paper is a preliminary report of a special investigation that has arisen in connection with the general study of source beds. An area on the west side of the Sacramento Valley in northern California underlain by a thick sequence of rocks of late Mesozoic age—that is, the Shasta series (Lower Cretaceous) and the Chico formation (Upper Cretaceous)—has recently been considered as prospective oil territory by several oil companies. Seeps of oil and gas are present and favorable structural features and reservoir rocks are known, but no oil in commercial quantity has yet been found. As the strata attain a thickness of 40,000 feet, the distribution of adequate source beds throughout this thick section is a very important question. The problem of the distribution of source beds was attacked by the writers by means of preliminary analyses of the organic content of 480 samples distributed fairly uniformly in the section, and by means of detailed analyses of the organic constituents of eight samples selected as being representative of these 480 samples. Definite conclusions about the possibilities of source beds in this area are difficult to reach because of the paucity of knowledge about the diagnostic characteristics of source beds. Nearly all the results that were obtained, however, lead to an unfavorable consideration of the sediments as source beds. The organic content is low and fairly uniform throughout the entire sequence of beds. The average organic content of the Shasta series is .87 percent and of the Chico formation .6 percent. The composition of the organic constituents of samples from the oil seeps is different from that of the sediments in the general section. This phenomenon suggests that sediments of the type that generate the oil at the seeps are not widely distributed through the general section.

The uniformity in quantity and character of the organic content of the Shasta and Chico sediments leads to the inference that almost any part of this sequence of strata is as likely to be favorable for source beds as any other part. Because of the failure to find oil in the wells that have already been drilled in this area, the uniformity of the organic content is not a favorable indication of the presence of adequate source beds of petroleum in the area. This inference about the uniformity of the organic content, however, is more encouraging with respect to source beds of gas, as significant quantities of gas have been reported from the Buttes well of the Buttes Oilfields Inc., and also from the Guinda well of the Nigger Heaven Dome Oil and Gas Co. However, despite the discouraging aspect indicated by the results of this investigation, the evidence is not very positive in character, and in no way condemns the area. It is entirely possible that adequate source beds may be present. (*Authors' abstract.*) Discussed by Miss STADNICHENKO, and Messrs. HESS, WHITE, and ROBINSON.

T. S. LOVERING: *Physiography of the Colorado Front Range.* Discussed by Messrs. MATTHES, WHITE, TRASK, KOSCHMANN, and BUTTS.

515TH MEETING

The 515th meeting of the Society was held in the Assembly Hall of the Cosmos Club, Mar. 28, 1934, President H. G. FERGUSON presiding.

Informal communications: H. D. MISER announced and discussed an angular unconformity on the northeast side of the Arbuckle Mountains. Discussed by Messrs. HENBEST and GOLDMAN.

H. G. FERGUSON on behalf of Mr. SHENON described fissures developed in the recent earthquake in Utah.

Program: J. C. MILLER: *The relation of geology to unit operation of oil and gas fields.* Discussed by Messrs. LOVERING and GAZIN.

R. W. BROWN: *The pronunciation of geologic terms.*—Above all other influences operating in the English language, the tendency to shift accent in a polysyllabic word from a root element to a new syllable that is meaningless, is the chief cause for diversity in the pronunciation of geologic and other scientific terms. Thus we hear ki-lom-eter for kilo-meter; ba-rom-eter for baro-meter; psi-lom-elane for psilo-melane; am-phib-olite for amphi-bolite; Dry-op-teris for Dryo-pteris; Quer-cox-ylon for Querco-xylon; Gas-trop-oda for Gastro-poda; tril-oba for tri-loba. The remedy for this situation is held to be a general agreement among scientists to disregard classical rules, for the most part, and to pronounce scientific terms so that the root elements can be heard as distinct units. (*Author's abstract.*) Discussed by Messrs. MATTHES, TRASK, SPENCER, LOVERING, MISER, and BOWMAN.

R. M. LEGGETTE: *Varved clay in Ogden Valley, Utah.*—Ogden Valley lies in the Wasatch Mountains about 10 miles east of the city of Ogden, Utah. It is a graben valley formed in early Tertiary time and is filled with more than 600 feet of unconsolidated gravel, sand, and clay. During the Bonneville stage of Lake Bonneville (5,200 feet) an arm of the lake extended eastward through a narrow canyon in the Wasatch Mountains and flooded Ogden Valley. Sediments were deposited during this high water stage that completely filled the valley up to an altitude of about 4,900 feet. With the overflow of Lake Bonneville and the cutting down of its outlet about 400 feet to the Provo stage, the Ogden Valley was drained and the streams began entrenching the 4,900-foot bench.

A deposit of varved clay, about 70 feet thick, underlies a considerable portion of the valley. A count of the varves on a number of specimens shows about 370 years per foot of varved clay. The more silty portions show about 160 years per foot. When these figures are applied to the clayey and silty portions of the total thickness of varved material it is found that about 23,000 years is represented by the 70 feet of varved clay. This does not represent an accurate figure, but should be considered only as indicating the general order of magnitude, perhaps 25,000 years.

The upper part of the varved clay lies above the level of the Provo stage of Lake Bonneville, and the clay, therefore, could not have been deposited during the Provo stage. The clay could not have been deposited in a small lake occupying Ogden Valley that was not connected to the main Lake Bonneville, because the varved clay lies higher than the overflow point of the valley through Ogden Canyon. The early Pleistocene stage of Lake Bonneville was high enough to allow the formation of the varved clay. However, there is no major break represented in the sediments above or below the varved clay and it is, therefore, believed that the varved clay and the overlying and underlying sand and gravel were deposited during the Bonneville stage of Lake Bonneville. The Bonneville stage presumably represents only a part of Wisconsin time and the varved clay which was deposited in about 25,000 years therefore represents only a part of Wisconsin time. (*Author's abstract.*) Discussed by Messrs. ALDEN, BRADLEY, FERGUSON, and THOMPSON.

516TH MEETING

The 516th meeting of the Society was held in the Assembly Hall of the Cosmos Club, Apr. 11, 1934, President H. G. FERGUSON presiding.

Informal communications: R. M. LEGGETTE discussed the recent earthquake in Ogden Valley, Utah, with epicenter at northeast corner of Great Salt Lake. The quake was recorded at well stations by water stage recorders and pressure recorders. Graphs were exhibited showing effects of earthquake registered by both types of recorders. The data suggest that the pressure recorders offer a new line of attack in earthquake study.

Program: H. D. MISER: *The Carboniferous rocks of the Ouachita Mountains.*—The Carboniferous rocks of the Ouachita Mountains are a great succession of sedimentary strata, chiefly shale and sandstone, measuring 18,000 to 20,000 feet in thickness in most parts of the region. The great quantity of sediments for these rocks was derived from the Paleozoic land Llanoria of Louisiana and eastern Texas and accumulated in the adjoining geosynclinal belt, which is concealed by Cretaceous and Tertiary deposits, except for the exposure in the Ouachita Mountains of Arkansas and Oklahoma, and other exposures in the Marathon and Solitario regions of Texas. All of the above thickness of Carboniferous rocks is of Pennsylvanian age, except for a few hundred feet of Mississippian shale (Caney shale) that is exposed in Ti Valley and at Wesley, Okla. If to this thickness of Pennsylvanian strata there be added the thickness of the younger Pennsylvanian rocks of the Arkansas Valley, the grand total reaches about 25,000 feet. The Ouachita Mountains and the adjoining Arkansas Valley, therefore, reveal the thickest known section of Pennsylvanian rocks in the United States.

In the past there has been much discussion about the age assignment of a large portion of the Carboniferous sequence. There has seemed to some geologists, including myself, to be some evidence for a Mississippian age assignment for the Hot Springs sandstone, Stanley shale, and Jackfork sandstone, and for a portion of a boulder-bearing shale on top of the Jackfork sandstone. On the other hand, there has seemed to other geologists, including Ulrich, to be much evidence for a Pennsylvanian age assignment for these formations whose combined thickness is about 12,000 feet.

The age significance of the plant evidence, which has been critically reviewed and studied by David White, is discussed by him in a manuscript paper given before the Dallas meeting of the American Association of Petroleum Geologists. An invertebrate fauna obtained by me recently from the Jackfork sandstone seems to be the first one to contain identifiable fossils of value. A statement concerning the age indications of the fauna has been given me by G. H. Girty. The evidence of the invertebrate and plant fossils is in agreement for indicating a Pennsylvanian age for the Hot Springs sandstone, Stanley shale, and Jackfork sandstone. A Pennsylvanian age assignment for the boulder-bearing shale has already been demonstrated by Bruce Harlton on the basis of microfossils.

With a Pennsylvanian age assignment for these formations it now becomes possible for me to reach a more satisfactory conclusion than I have been able to reach hitherto, concerning the nature and origin of the boulder-bearing shale which rests upon the Jackfork sandstone. This shale is here designated Johns Valley shale, in accordance with E. O. Ulrich's usage proposed in 1927. The deposits of erratic boulders are found along and near the northern margin of the Ouachita Mountains and lie within the Oklahoma structural salient, whose northern frontal margin marked by the Ti Valley fault has been thrust toward the northwest, a distance of 20 miles or more over rocks of the Arbuckle Mountain facies. The boulders have, I believe, been derived from an early Pennsylvanian uplift which has been largely, if not entirely, concealed by the northwestward overthrust of the Oklahoma

structural salient in late Pennsylvanian time. My ideas of the location of the uplift thus accord with those as expressed by Sidney Powers.

I question the ice-rafting hypothesis for the transportation of most of the erratic boulders because of the great size of the erratic masses of Caney shale (Mississippian) measuring as much as 600 feet across, that are embedded in the Johns Valley shale (Pennsylvanian), because of the great size of many limestone blocks measuring as much as 370 feet long that are found in the Johns Valley shale, and because of the apparent local source of the exotic material. E. E. L. Dixon's hypothesis that the boulders represent submarine land slips from high scarps on the uplift that has been postulated by Powers, seems to accord with most of the available evidence. The hypothesis for the origin of the boulders by thrust faulting seems to have fatal objections. There are no repetitions in the sequence, as would be expected from overthrust faulting. Nor are any of the boulders found along the faults that bound the northwestwardly overthrust sheets of the Oklahoma structural salient. Instead, the boulders are confined to a single formation, the Johns Valley shale.

The orogeny forming the hypothetical uplift from which the erratic boulders may have been derived in early Pennsylvanian time appears to have taken place coincident, or nearly coincident, with a widespread early Pennsylvanian orogeny that, according to C. W. Tomlinson, Sidney Powers, and Robert H. Dott, affected a large region in southern Oklahoma, including the Criner Hills and Arbuckle Mountains. (*Author's abstract.*) Discussed by Messrs. ULRICH, FOERSTE, STOSE, and FERGUSON.

DAVID WHITE: *The age of the Stanley and Jackfork formations.* Discussed by Messrs. MISER and ULRICH.

517TH MEETING

The 517th meeting of the Society was held in the Assembly Hall of the Cosmos Club, April 25, 1934, President H. G. FERGUSON presiding.

Program: A. H. KOSCHMANN: *The geology of the new deep tunnel of the Cripple Creek District.* Discussed by Mr. MANSFIELD.

G. F. LOUGHLIN: *Groundwater and deep ore reserves of the Cripple Creek District.* Discussed by Messrs. GILLULY, LINDGREN, FERGUSON, and GOLDMAN.

W. H. BUCHER: *Limestone blocks in volcanic breccia on Shoshone River, Wyoming.* Discussed by Messrs. LOUGHLIN, KOSCHMANN, FERGUSON, WOODRING, LARSEN, GILLULY, BRIDGE, HESS, TRASK, ALDEN, and MISER.

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

Biological Survey, U. S. Department of Agriculture.—JAY N. DARLING and W. C. HENDERSON, chief and associate chief, respectively, of the Bureau of Biological Survey, on September 11 addressed the International Association of Game, Fish and Conservation Commissioners at their annual meeting in Montreal. Outlining the Bureau's program for national wildlife restoration, Mr. DARLING spoke on *Conserving and restoring waterfowl.* Mr. HENDERSON in a paper entitled *The waterfowl crisis* summarized the results of the extensive studies recently made by the Biological Survey.

On September 6, Mr. HENDERSON discussed wildlife and forestry at a forestry-and-land-use session of the annual forestry conference held in Plymouth, N. H., by the Society for the Protection of New Hampshire Forests in

cooperation with the New Hampshire Forestry Commission. W. L. McAtee and J. Paul Miller also represented the Biological Survey at the conference.

National Bureau of Standards.—On recommendation of the Department of State, Dr. J. H. Dellinger, chief of the radio section, was appointed chairman of the American delegation to the International Radio Consulting Committee which met in Lisbon, Portugal, from September 22 to October 10. The other official delegates were Major Roger B. Colton, Signal Corps, United States Army; G. C. Gross, Federal Communications Commission; Captain Stanford C. Hooper, United States Navy; and W. Vallie Whitington, Treaty Division, Department of State.

The International Radio Consulting Committee was established in 1927 to advise the radio administrations of the world on technical questions, the principal objective being the reduction of radio interference. Shortly after the committee convened in Lisbon, Dr. Dellinger was elected one of the vice presidents.

Dr. Dellinger also attended a session of the International Scientific Radio Union in London, September 11 to 19. This is one of the organizations in the International Council of Scientific Unions in which the United States is represented through the National Research Council. The London meeting dealt with radio measurements and standards, propagation of waves, atmospherics, and radio physics. Four reports were presented by Dr. Dellinger on radio frequency standards, analysis of continuous records of field intensity at broadcast frequencies; frequency distribution of the intensities of radio atmospherics, and report on Polar Year observations.

The American Congress of Physical Therapy has announced the award of its gold key, "the highest honor within the power of the Congress to bestow," to Dr. W. W. Coblentz, chief of the radiometry section of the National Bureau of Standards, and member of the Council on Physical Therapy of the American Medical Association, "for meritorious service to medical science in the field of ultra-violet radiation."

National Park Service, U. S. Department of the Interior.—Director Arno B. Cammerer, Assistant Director Harold C. Bryant, and Chief Naturalist Earl A. Trager have returned to Washington from extensive western park trips.

Former Director Horace M. Albright of the Service has been honored in the naming, as *Albrightia*, of one of our genera of algae segregated and identified by Dr. Joseph J. Copeland, New York scientist, while in Yellowstone National Park during the past summer. Another newly indentified genus has been given the name *Coulteria*, for the late Prof. John Coulter of the University of Chicago, who began his botanical career as a member of the Hayden Expedition of 1872.

Children's Bureau, U. S. Department of Labor.—Cooperating with the Institute of Human Relations and the Pediatric Department of Yale University School of Medicine, the Children's Bureau is undertaking this autumn a three-year study of the physical fitness and growth of a group of school children in the public schools of New Haven. The purpose of this study is to evaluate certain indices of nutrition and development of children. It is proposed to examine approximately 1,200 six-year-old children entering the schools in September. A series of physical measurements will be made. At

the end of three months the children will be reweighed, and thereafter every three months during the year. The same group of children will be re-examined in the fall of 1935, and again in the fall of 1936 by the same physician.

At the request of the National Industrial Recovery Administration, the Children's Bureau, together with the Women's Bureau of the U. S. Department of Labor, is making a study of industrial home work in different localities. Field work has been carried on in Maine, New York, New Jersey, and Philadelphia and will be continued in Connecticut, Iowa, Illinois, and Texas. Tabulation of findings has already begun. Home work industries studied include those in which home work is still permitted without regulation, those in which it is regulated, and those in which it is now prohibited, information from the last being obtained in order to show how the manufacturers and employers have adjusted their industries to the prohibition of home work. The information obtained in this study will cover hours worked and rates paid for home work, the number of children engaged in these occupations, and other data which will provide a basis for dealing with this problem by the NRA.

Bureau of Fisheries, U. S. Department of Commerce.—At the twenty-first meeting of the North American Council on Fishery Investigations, held at Halifax, N. S., on September 19, the United States delegation consisted of Dr. H. B. BIGELOW, chairman of the Council, CHARLES E. JACKSON, deputy commissioner of fisheries, and ELMER HIGGINS. Also in attendance from the Bureau of Fisheries were O. E. SETTE and W. C. HERRINGTON. The meeting was uniquely notable, in that it was the first one of the Council in its fourteen years of activity to be held on what is technically French soil. The sessions were held on board the new French fisheries research vessel *President Theodore Tissier*. The next meeting of the Council will be held in Washington, D. C., in September, 1935.

Recent researches by Dr. P. S. GALTSOFF, chief oyster investigator, assisted by J. F. REPPUN, indicate that while spawning of the females of the native North Atlantic oyster species can be stimulated by the presence of sperm from Japanese oysters, such spawning will not occur in response to sperm from a number of other mollusks or from echinoderms. Dr. GALTSOFF has also shown that the oyster sperm contains an active principle or hormone-like compound which can be isolated. A quantity of this compound has been prepared and is being used in biological studies.

The Venezuelan Legation has arranged with the Bureau of Fisheries for a consignment of miscellaneous river fishes to be shipped to Venezuela, where an effort will be made to propagate them for introduction in the fresh-water bodies of that country.

American Chemical Society.—Five Washington men have been elected to fill posts in the American Chemical Society. They are: Dr. WILLIAM D. APPEL of the Bureau of Standards, who will head the Division of Dye Chemistry; Dr. HORACE T. HERRICK of the Color and Farm Waste Division, Bureau of Chemistry and Soils of the U. S. Department of Agriculture, secretary of the Dye Division; Dr. CHARLES A. BROWNE, also of the Bureau of Chemistry and Soils, member of the Executive Committee of the Division of History and Chemistry; Dr. ALDEN H. EMERY of the U. S. Bureau of Mines, re-elected secretary-treasurer of the Division of Gas and Fuel Chemistry, and Dr. CLAUDE S. HUDSON of the Hygienic Laboratory will serve on the Executive Committee of the Division of Organic Chemistry.

Georgetown University School of Medicine.—The Rev. DAVID A. MCCAULEY, S.J., chairman of the department of biology was appointed to succeed Rev. JOHN L. GIPPRICH, S.J., as regent of the Schools of Medicine and Dentistry. Father MCCAULEY is a native of New York City and entered the Society of Jesus in 1913. He was successively assistant professor of biology at Fordham University, professor of biology at Holy Cross, and later at Canisius College, and finally he was for the past three years professor of empirical psychology and biology at the Jesuit Seminary at Woodstock, Maryland. Father MCCAULEY is a morphologist by training, and his special field of interest in the field of exact sciences is neuro-anatomy.

Mr. GEORGE A. BENNETT resigned as professor of anatomy. Dr. JOSEPH L. SCHWIND formerly of Cornell University College of Medicine was appointed professor of anatomy and acting chairman of the department. The following appointments have also been made in the department of anatomy: Dr. JOHN J. LAWLESS, and Dr. RUSSELL L. JONES, both formerly of the University of Minnesota, as instructors in anatomy.

The following special lecturers have been appointed in the department of bacteriology: Dr. R. E. DYER, assistant director, Dr. CHARLES ARMSTRONG, surgeon, Dr. EDWARD FRANCIS, medical director, and Dr. R. R. SPENCER, surgeon, all of the National Institute of Health. They will give lectures on rickettsia, smallpox vaccination, tularemia, and dysentery respectively.

The department of pathology purchased a new sledge microtome for cutting sections of whole organs. Prof. WHITMORE is continuing his work on the biologic action of radiant energy and the endocrine origin of lesions in bones and in the breast. Associate Professor DARDINSKI has just completed the anatomical study of the ampulla Vater in different morbid conditions.

The department of pharmacology purchased apparatus for extensive toxicological research and for the study of placental permeability of drugs. Prof. T. A. KOPPANYI and his associates published numerous papers on the colorimetric estimation of veronal derivatives and on the action of bartiturates in the living tissue. As a result of these researches a new conception of anesthesia was developed. Dr. KOPPANYI and his associates also succeeded in the experimental production of lasting intracranial hypertension.

George Washington University School of Medicine.—The School celebrated the opening of the one hundred tenth academic year on September 19. Addresses were delivered by President CLOYD HECK MARVIN president of the University and Dr. WILLIAM J. MALLORY, professor of medicine. Among the distinguished visitors and guests present were Prof. JOHN REENSTIERNA, department of bacteriology, University of Upsala, Sweden; Capt. HAROLD SMITH, Commandant, United States Navy Medical School, and Col. P. W. HUNTINGTON, Commandant, United States Army Medical School. Dr. E. B. MCKINLEY, dean of the School of Medicine, announced the following new appointments to the teaching staff: Dr. HERBERT P. RAMSEY, assistant professor of obstetrics and gynecology; Dr. WADE H. MARSHALL, instructor, department of physiology; ALMA FOGELBERG, instructor, department of physiology; Dr. RANDALL L. THOMPSON, research associate in bacteriology; Dr. IRMGARD DRESEL, instructor, department of pathology; Dr. ELIZABETH RAMSEY, instructor, department of pathology; Dr. DUANE CASE RICHTMEYER, research assistant in experimental medicine; Dr. G. LOUIS WELLER, Jr., clinical instructor in medicine; Dr. HARRY F. DOWLING, clinical instructor in medicine; Dr. RUSSELL F. FIELDS, clinical instructor in dermatology and syphilology; Dr. BYRON RIEGAL, research assistant in

biochemistry; Dr. ALEXANDER SIMON, clinical instructor in neurology; Dr. KATHERINE E. PARKER, instructor in obstetrics and gynecology.

NEWS BRIEFS

The thirty-fourth annual conference of the Federation Aeronautique Internationale was held in Washington, October 6 to 11. The program included a visit, on October 7, to the laboratories of the aeronautic instruments section of the National Bureau of Standards. Dr. W. G. BROMBACHER, chief of the section, had some interesting instruments and testing equipment to show the visitors. The Federation is the aviation sport governing body of the world, the United States being represented through the National Aeronautic Association. In all, twenty-one nations were represented at the conference.

Because of the adverse ruling of Comptroller McCarl, the Forest Service will be unable to begin the immediate development of the great shelter-belt project in the West. Approximately one million dollars at present available will be expended in research, exploratory work, and the expansion of nursery stocks, to be used in the event that the next Congress makes an appropriation for this purpose.

A strong appeal for the rescue of the almost extinct trumpeter swan has been issued by Secretary of the Interior HAROLD F. ICKES. At present, the remnant of the species is confined almost entirely to the waters of Yellowstone National Park and the immediate vicinity.

Preliminary studies are under way at the Catholic University of America looking to the possible establishment of an "alphabet grove," a famous institution in ancient Ireland, in which each of the eighteen letters of the Irish alphabet was represented by its "name tree."

PERSONAL ITEMS

Under Secretary of Agriculture REXFORD G. TUGWELL was official representative of the U. S. Department of Agriculture at the autumn meeting of the International Institute of Agriculture, at Rome.

Dr. AGESILAU BITANCOURT, associate director of the plant division of the Biological Institute of the Department of Agriculture of the State of Sao Paulo, Brazil, was the guest of the U. S. Department of Agriculture during the latter part of September.

Dr. HANS LAUER, professor of ophthalmology, the University of Warsaw, Poland, addressed the faculty and students at the school of medicine, George Washington University, on Tuesday, October 2. Dr. Lauer's subject was, *Heredity, particularly in relation to the eye.*

Dr. J. E. I. CAIRNS, of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, who has been stationed at the Huancayo Magnetic Observatory, in Peru, since August 1931 and in charge of the Observatory since December 1, 1932, returned to Washington, D. C., on September 27.

F. T. DAVIES, of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, who has been on furlough since February 16, 1932,

in order that he might take part in the Polar Year work at the Canadian station at Chesterfield Inlet, and afterwards participate in the reduction of the observations at the Meteorological Service, Toronto, returned to take up his duties at the Department of Terrestrial Magnetism in October.

Miss RUTH O'BRIEN, chief of the division of textiles and clothing, bureau of home economics, U. S. Department of Agriculture, spoke on *Standards for consumers' goods* before the meeting of the Conference on Distribution, Boston, on September 25.

Dr. CHARLES F. ROOS, chief of the research and planning division of the NRA, and from 1930 to 1932 permanent secretary of the American Association for the Advancement of Science, has been appointed professor of economics at Colorado College.

Correction.—With reference to the paper *Pleistocene remains found near Lake Tacarigua, Venezuela* by Charles Berry, published in this JOURNAL **24**: 387–395, October 1934, the author wishes to add a statement to the effect that the term *Pleistocene* was used in a loose sense for everything from Pleistocene to Recent, since there was no means of making a distinction at that locality.

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PHYSICS.—*The beginnings of physics. I.—The quest for general principles.*[1] Raymond J. Seeger, The George Washington University.

When, where and how did physical science begin? To answer these questions, we must first of all specify what is meant by physical science. This we can do only by tracing its outline in historical perspective to the central focus of all ages. But considerable care must be exercised in allowance for the distorted lines of particular periods and for the faint marks of primitive times. Shall we seek the origin of science in the early use of tools? If so, archaeological history assigns the drill and the potter's wheel to some time before 3000 B.C. Even as to-day, however, a child acquires mastery of a hoop without perceiving the latent dynamical principles, so too the ancients had no knowledge commensurate with their mechanical skills. It would seem better to seek for the beginnings of science in the first conscious investigations of nature. At once, we think of the early cosmogonies of mythology. But we hesitate to ascribe to these the spirit of science. Although both mythology and science start with keen observations, the former regards men; the latter, things. Mythology interprets nature subjectively in terms of human experience; science describes it objectively in terms of its own. Such methods are incompatible. Indeed, science could arise only if the old way of thinking were completely discarded. For mythology could be modified in no simple manner, inasmuch as anything new would have to be added to the old for safety's sake. Consequently, a different attitude had to be developed—not a broadening, but a narrowing of animistic views—so that objective study would be ultimately possible. Such a reactionary method necessitated an intellectual revolution for its inception. And this is just what took place in Greece about 600 B.C. when thinkers began the quest for general principles which would describe nature without recourse to caprice.

New ideas germinate readily in a new country. And in a certain sense Greek Ionia, which was the western part of what is now Asia

[1] Received July 2, 1934.

Minor, was "a country without a past." Its inhabitants were adventurers who had come from Attica after the Dorian invasion from the north. They had left behind the decadent religion molded by Hesiod's *Theogony*. The Ionians, therefore, were free to explore unrestricted realms of thought. Their curiosity created pure research, that disinterested search for truth which is immortalized in the oath of Hippocrates[2] of Cos (c.400 B.C.). To be sure, vestiges of Olympian polytheism always remained. For example, Thales, one of the seven wise men of Greece, said with reference to magnetism, which he had discovered, "All things are full of gods." But this is trivial compared with the magnificent conception of a first cause, which the Ionian philosophers proposed as materialistic in nature. Later this was extended to the Aristotelian hierarchy of four causes, in which teleology humanized logic with ethics. Hence, in time, philosophy became a way of life and the "lovers of wisdom" adopted this new *raison d'être* for their studies. Their criterion was so universally accepted that a divergence between professional philosophy and science has been perpetuated to this day.

Claims have been made that science was transmitted in the contacts of the sea-loving Ionians with Chaldean astronomers and Egyptian geometers. There is no doubt that the acquisition of many facts is to be attributed to the excursions of these men from Eastern Greece. But the philosophical interpretation of the facts was peculiarly their own. The astronomy of Chaldea was mainly astrology interspersed with some practical methods for predicting eclipses. The geometry of Egypt was, at first, no more than empirical mensuration. It took a Pythagoras to realize the significance of the 3–4–5 rule used by the "rope-stretchers" along the Nile. As for the older civilizations of India and China, the historical facts are too few to warrant more than vague conjectures. What is definitely known is that an entirely different approach to the understanding of the universe was begun in Greece more than a century before the "golden age" of Pericles.

The scientific method of the Greeks has often been ridiculed because of its lack of experimental justification, not to mention its permeation with speculation. We note, however, that even the latter is decidedly experiential. Do not savages fear the potentially evil spirits lurking in the clouds because storms actually do rage? The Greeks could hardly be said to be less observant. Indeed, the literary

[2] Dates and spellings of Greek names are taken from the *Introduction to the history of science*—George Sarton (1927).

descriptions of Homer and the delicate sculpture of Phidias are eternal evidence of their attention to minute details. The biological classifications and records of Aristotle still excite the admiration of naturalists. What amateur of science has not been thrilled by Hipparchos' discovery of the precession of the equinoxes? As a matter of fact, such instances can be so readily multiplied that the speculative character of Greek conclusions can not have been inherent in their observations. On the contrary, it grew out of their unobserved significance. How else can one account for nature being accepted as the giver, but not as the judge of theory? Induction, it is true, was used. But in what way? Solely as the grouping together of similar observations. Nature was never examined as to the reason for their similarity or the possibility of their not being universal. The facts were regarded as concrete symbols of abstract reality; they were looked upon as incidental expressions. Accidental impressions were overlooked; for epistemology with its incisive analysis of mind itself was yet to come. Even Protagoras' hint that man is a measure of all things and Xenophanes' earlier application of it to the anthropomorphic gods were but eddies in a tide of self-satisfaction. And so when objections to any hypothesis were made on the basis of new facts, the tendency was to deny these rather than to modify the theory.

To-day we can understand all this psychologically as the "will-to-live" of their newly born enthusiasm, the supreme power of thought. Sublime as this may have been in the mind of Plato (or later of Hegel), however, it has been found to take too little cognizance of man's abilities and of nature's intricacies. Modern physicists very guardedly refrain from any semblance of finality in their small restricted domain. But in the childhood of science the intellect loomed as an all-powerful giant. Had not the dialectic method of Socrates disarmed the sophisticated sophists and freed truth from their mesh of error? The Greeks were eager to apply it unreservedly to everything. Moreover, the rational architecture of the universe seemed to them to call for an investigation of the universal elements of design. So experiment was cast aside as dealing with comparatively insignificant matters. Nor did it adapt itself later either to the ethical philosophies of the Greek world or to the Christian theology of the Roman empire. In an age, therefore, when methods were being formulated, the *a priori* method won support because of its quick returns. The operation of a similar natural selection can be observed to-day in newly developed fields

where the base achieving of results receives more plaudits than the acid testing of methods.

The real contributions of Greece to physical science have been the enunciation of general principles and the application of mathematical symbolism. When we compare these advances with the blind ignorance of the preceding age and with the stereotyped knowledge of the following one, we are almost converted to a belief in a "heroic age of science." We shall examine the second contribution in Part II. For the present, let us take up the general hypotheses in logical detail in order that too many lacunae may not give them the appearance of being merely a catalogue of desultory opinions. For one can trace a definite trend toward a clarification of concepts. Indeed, in some instances the final ideas seem almost identical with our own, but the language expressing thoughts must always be understood in the context of the age considered. In particular, it must be borne in mind that whether or not any general theory is ultimately successful is not indicative of its importance when first presented, inasmuch as the success of speculation is no more to be credited than its failure. Because of subtle inferences that can be made, true results by false methods are just as confusing, as worthless results by genuine methods.

Is it possible to give a unified materialistic explanation of nature? In other words, can one rationally interpret phenomena on the basis of a simple kinematical picture? The very question is startling. It becomes more so when we pause to examine its tacit assumptions as understood by the Greeks. In the first place, there is a belief in the uniformity of nature, i.e., a certain regularity of sense-perceptions that seems to invite the direct application of causality, as for example the continual succession of day and night. Secondly, a faith in man's capacity for understanding such orderliness is affirmed. Finally, quintessential truth is unreservedly sought. To-day we still ask the same question, but our frank skepticism calls boldly for specific qualifications. We feel free to consider the uniformity in certain cases an average condition, as when a large lake appears calm because its playful ripples escape our notice. Then too, man's ability to synthesize his experiences, we believe, arises partly from his own peculiar analyses. The strange imprint upon nature is his own. As for the true explanation of the universe, this has been abandoned as a scientific project *per se*, and has been replaced by the more modest search for an adequate description of it. Perhaps, there is a unique picture of the real world; then again, there may be several that are

equally satisfactory. Science is concerned with the sufficiency of its theories, not with their necessity; at present, of course, it will be content to find a single one. On the other hand, it is interesting to note that several pictures may be necessary (cf. the wave-theory and the corpuscular theory to-day). The following example may serve to illustrate the modern viewpoint. One says, "He was a lion in the fight." We all understand what is meant. The picture aptly describes a certain characteristic of the individual, but is the picture literally true? Was there actually a metamorphosis? That is a matter which cannot be settled without additional information. Furthermore, we note that another picture might tell the story just as well. One might also say, "He would not give up the ship." So, too, science leaves this sense of the reality of its picturesque descriptions to be determined by other means. Let us now examine the hazy pictures which were sketched by the Greeks.

Thales of Miletos (n.624 B.C.), the father of physics, selected water as the primordial substance. Despite the fact that none of his writings are extant, we can reasonably attribute his choice to its omnipresence. Water is everywhere; in the rains that descend upon the earth, in the waters under the earth, in the oceans about the earth. It permeates all substances so that their physical properties are dependent upon their content of moisture. Even life is conditioned by its presence. This universality of water served as the first requisite of the basic material. Furthermore, the readiness with which water transforms into solid and into vapor hinted at mobility, another necessary characteristic, but Thales himself gave no particular explanation of any such changes. In order to do so, his pupil Anaximander (c.610–545 B.C.) decided to introduce a different primary substance which was an "ageless and deathless" substratum of matter. This unchanging reality, which he called φύσις ("characteristic property of something"), had derivatives such as water and air resulting from its natural dissociation into pairs of neutralizing components (cf. the rainbow from sunlight). For as one observes phenomena, one is impressed with the duality of changes; here drying occurs, there moistening; now heating, then cooling. To be sure, this is merely the twofold aspect of the reversibility of changes, but it is susceptible to manifold interpretations. In the one we are considering, the very constancy of such changes necessitated a continuous dissociation of the primary substance so that it had to be more plentiful than sand on a beach washed silently by time-telling tides. But no common material is so abundant; hence, the need for something

"boundless" and insensible. Thus for the first time an eternal submatter (like the electrons, protons, etc. of modern physics) had to be proposed. The significance for us lies in this choice of a hypothetical substance to account for actual materials, an unseen universe to represent the visible one. As for the principle of indestructibility which was also suggested, it has been invoked in modern times for the conservation of mass, the conservation of energy, and the conservation of electric charge. Challenged in the 20th century, it has been merely transferred from matter (i.e., charge) to a more fundamental concept, viz., that of energy, so that matter itself is to be looked upon as an accidental form of energy. It would be of interest to examine Anaximander's doctrine of an eventual compensation of the "opposites" to produce a changeless universe and his view of the earth as freely supported. We prefer, however, to confine our attention more strictly to the development of ideas which to-day are the tacit assumptions of physics ("the study of φύσις"). Such is the proposal of a unified, materialistic explanation of all phenomena, which was a volcanic eruption in a world governed by the uncontrollable passions of humanized gods and enveloped in the dark atmosphere of ignorant superstition.

Another important step in the search for unity was made by Anaximenes (fl.546 B.C.), an associate of Anaximander. Retaining the idea of the "boundless," he decided it was air, but rejected Anaximander's other views as so indefinite as to be meaningless. The reason he chose air in preference to water is evident in his way of accounting for the derivatives of the "boundless." When one whistles, the air is cool; when one yawns it is warm. He reasoned, therefore, that condensation produced cold air, whereas rarefaction produced warm. The variety of materials could thus be explained in terms of the variations of a single substance, e.g., ice, water, water-vapor. But to ascertain, in general, whether materials are fundamentally distinct or different forms of some single identity is a theoretical problem which cannot be uniquely solved. Then, too, what may appear simple at first sight may prove too complicated to establish as such. And so we must regard the entire proposal of Anaximander as a simple hypothesis which failed of a simple proof. For he advanced the notion that fire was air in a very rare state. Upon condensation it became first wind and then cloud. Obviously, condensed cloud gave rise to water which disappeared into earth itself, and condensed finally into stone. Hence, the process of transformation, which his predecessor had left indeterminate, he was able to trace in the varying

conditions of air. Above all, the states of heating and of drying which had previously been logical hybrids of indeterminateness and mobility could be stated by use of condensation and rarefaction (cf. the whistling example, above). Although the advantages of thus describing qualitative differences by quantitative variations in state is too common to-day to be fully appreciated it was a clear-cut departure from the current meanderings at that time. For fluid theories are usually the first conceived in any age—perhaps, because of their ease of apprehension. One still recalls the phlogiston of the 18th century and the caloric of the 19th (it is strange that Lavoisier disproved the former, but approved of the latter)—not to mention the "neutrinos" of 1934. And so it is to the credit of the Greeks that the philosophy of Anaximenes became the accepted one of the Milesian school at an early stage.

Heraclitos of Ephesos (fl.500 B.C.), who desired to be considered apart from the other Ionian philosophers, perceived in the constancy of change, not so much a transformation of a single substance, as a single transforming. In other words, he sought unity in the activity rather than in the passive object. For example, consider the burning of wood. The flame plays from place to place while the burning steadily proceeds. It is change alone which is lasting; all else is ephemeral. And what is the most spectacular producer of change but fire? Out of fire, therefore, comes everything, as when the burning wood yields smoke and ashes as by-products. To Heraclitos this illustrated the essential nature of the universe. For from the fire of the sun leaped "fiery water-spouts," which burned and left earth as a residue. The earth was then carried away to the sea where it returned to the sun by the evaporation of the water. The cycle was repeated. More than that, it was reversible so that at any instant the sea should be considered a mixture of fiery water-spouts becoming earth and of earth becoming fiery water-spouts. These opposing transformations so balanced each other that one might appropriately speak of their harmony from the analogy of a note produced by the pull and strain on a string of a lyre. For is not the warm ever cooling; the cool, warming? Each is only a different aspect of the same equilibration. Fantastic as this may appear, Heraclitos made a real contribution in his emphasis upon dynamic equilibrium, viz., his subjecting mobility, as well as matter, to definite laws. We note in all these speculations a gradual insistence upon logical application rather than poetic license. But weak spots of analogies were often left unprotected and became sores for later irritation. In this case, by the way, what was

the exact relation between fire and its by-products (not solved until the 18th century)? This question soon absorbed the attention of the philosophers until two answers came into vogue; one denied the very existence of change, the other affirmed the existence of several primary substances instead of a single one. In fine, the quest for a primordial substance and the emphasis upon motion were found to be incompatible.

It was Parmenides of Elea (c.539 B.C.), who pointed out that the "real" must be uncreated and indestructible if matter alone could be thought, but how, then, could one interpret the transformations of the "real"? Manifestly on a monistic view these were incredible. All appearance of change was necessarily an illusion of the senses, as well as any sensation accompanying it. This meant that the world was one homogeneous body of matter without any space whatsoever and that motion was impossible. This strange attitude, which was only the logical development of a purely monistic view, was responsible for the subsequent abandonment of monism. Pluralism of some kind was adopted—until reality was assigned not only to sub-matter, but even to the non-corporeal. Our chief concern lies in the discrediting of the senses and the insistence upon logical consistency. For he stressed the need of differentiating between primary matter and its secondary qualities. The world of nature became even more a world of the mind.

The first attempts to use more than one funadmental substance were in the form of combinations of those which had already been proposed for a single one. Oenopides of Chios (c.500–430 B.C.) chose fire and air; Xenophanes of Colophon (fl.540 B.C.) preferred water and earth. It remained for the Dorian philosopher, Empedocles of Acragos (c.490–435 B.C.), to combine all four. Indeed, this was not wholly unreasonable inasmuch as this group included a solid, a liquid, a gas and ethereal fire. He really introduced the idea of "elements" (a name employed first by Plato), which were constituents of all materials. Strictly speaking, the early Greek philosophers recognized six. For in addition to fire, air, water and earth, love and strife were considered to have certain corporeal properties such as length and weight. These last two elements (like our modern attractive and repulsive forces) were supposed to set the others in motion. Combinations of any number or of all six were assumed to produce the various kinds of matter. To cite an instance, "bone consists of 4 parts of fire, 2 parts of earth and 2 parts of water." Of course, *a priori* methods were used to determine the relative amounts in a

composition. But the idea of combinations of a few elements to account for many substances proved very potent throughout the growth of science; and we must remember that it was the atomists who first took up this problem of the way elements combine in order to explain the secondary characteristics of matter composed of similar particles. The same foundations of physics were laid carelessly on the shifting sands of speculation, before they were laid critically on the bed-rock of experiment.

In the meantime, another philosopher, Anaxagoras of Clazomenae (c.499–428 B.C.), one of the first martyrs of the freedom of thought, suggested at Athens the very opposite extreme to the unity advocated by Parmenides. The following quotations[3] epitomize his viewpoint. "How can hair come from what is not hair, or flesh from what is not flesh?" (The argument is still used by opponents of certain biological theories.) "For there is no least of what is small; there is always something still smaller. For it is impossible that that which is should cease to be by being divided. In everything there is a portion of everything except mind." Although this proposal was diametrically opposed to that of Parmenides, it was raised to solve the same dilemma, viz., that creation and change were impossible because matter could not come from nothing. There is no doubt that Anaxagoras offered a rational, though not reasonable, answer. For there were just as many seeds (to borrow the name used by Aristotle) as substances. If one asked, then, how bread could become flesh upon digestion, the ready reply was that bread had flesh latent in it. To be sure, the "flesh-seeds" had to be very minute and sparsely scattered throughout the bread. Otherwise, as Anaxagoras might note, one would have to expect wood shavings when cutting hair. The seeds were to be regarded as infinitely divisible, but never lost. Thus the permanence of substances was maintained despite disruptive changes. Somewhat apart from other seeds were those of the mind. Like Empedocles' strife and love these corporeal bits caused motion. Certainly Anaxagoras' solution of the problem of change was naïve. It was not satisfactory, however, in that the sufficiency of an explanation is not the only objective of natural philosophy. It must be simple also. (Recall the remark of Kepler: "Nature loves simplicity and unity"—or at least, mankind loves them.) And so atomism arose out of a desire to reduce the number of basic substances and to refute the Eleatic notion that phenomena were illusions. Let us turn again to Parmenides' views.

Zeno of Elea (fl.402 B.C.) introduced an entirely new method of

[3] *Source book in ancient philosophy*—CHARLES M. BAKEWELL (1907) 51.

proof in defense of Parmenides' monism. It was essentially a *reductio ad absurdum.* The object was to show that an opponent's arguments were erroneous by deducing some absurd conclusion, or better, to obtain incompatible conclusions from the same hypothesis. Zeno used this method chiefly to disprove the pluralistic mathematics of the Pythagoreans, e.g., that space was made up of a number of mathematical units. "A point is unity having position." His famous paradoxes hinted at the great caution that must be employed, not only in the technical application of mathematics to physical problems, but also in the philosophical interpretations. For mathematics can express only what it has been asked to express. The paradoxes[4] themselves illustrate most clearly Zeno's method.

(1) "*You cannot cross a race course.* You cannot traverse an infinite number of points in a finite time. You must traverse the half of any given distance before you traverse the whole, and the half of what remain before you can traverse the whole. This goes on ad infinitum, so that there are an infinite number of points in any given space, and you cannot touch an infinite number, one by one, in a finite time.

(2) "*Achilles will never overtake the tortoise.* He must first reach the place from which the tortoise started. By that time the tortoise will have got some way ahead. Achilles must then make up that, and again the tortoise will be ahead. He is always coming nearer, but he never gets up to it.

(3) "*The arrow in flight is really at rest.* For if everything is at rest when it occupies a space equal to itself, and what is in flight at any given moment always occupies a space equal to itself, it cannot move.

(4) "*Half the time may be equal to double the time.* Let us suppose three rows of bodies, one of which (A) is at rest, while the other two (B, C) are moving with equal velocity in opposite directions. (See the following diagram.) By the time they are all in the same part of the course B will have passed twice as many bodies in C as in A. Therefore, the time which it takes to pass C is twice as long as the time it takes to pass A. But the time which B and C take to reach the position of A is the same. Therefore, double the time is equal to the half."

Beginning		End	
o o o o	A	o o o o o	A
o o o o →	B	o o o o o	B
← o o o o	C	o o o o o	C

The mathematical subtleties involved in these problems are continuity, infinitesimals and absolute infinity or transfinite numbers so that even to-day the explanations are far from simple. The funda-

[4] *Early Greek philosophy*—John Burnet (3rd ed. 1920) 318.

mental question is whether or not the limit of the variable is reached by it, e.g., whether Achilles ever does overtake the tortoise. But mathematically, this must be defined to suit the physical observation, and so Zeno's difficulty is removed. Here we are face to face with a typical example of mathematical logic transcending intuitive physics or, in other words, a method of analysis which cannot be analyzed into simple, physical commonplaces just as the recent quantum mechanics cannot be understood by reduction to familiar descriptive models. As for Zeno, he was content with having vitiated the arguments for more than one "real," by showing that motion could not be conceived in terms of a finite number of space-units. Of course, infinite divisibility of space was rejected because it seemed to lead to an infinite number of finite parts (again a question of the meaning of a limit such as zero).

It may seem strange that a theory of invisible atoms should have its origin in a refusal to disbelieve what is seen. Yet this has always been the case from the time they were first proposed by Leucippos of Miletos (c.460 B.C.) to the 20th century. Starting with a firm belief that knowledge is acquired through the senses, he proceeded to solve the logical difficulties encountered by Anaxagoras and by Zeno. First of all, he assigned existence to the non-corporeal and classified space as such so that motion was no longer an illusory experience, but again an accepted fact. Secondly, he postulated atoms ("uncut bits"), which were all of one substance, homogeneous, hard and indivisible. But why, we may ask, these particular attributes? The first two made it possible to retain the unifying principle of a single material. Instead of the one plenum of Parmenides, however, each atom now possessed such properties. The hardness of the atoms insured their changelessness and timelessness. Finally, their indivisibility relieved everyone of any fear that matter might fritter away into dust like the seeds of Anaxagoras. Let us consider the reasons adduced to support the atomic hypothesis. It was natural to suppose that there is a physical limit to the cutting of any body. The knife itself guarantees that. Such an undivided portion could usually be seen, so that one had to think of the cutting as being repeated indefinitely until the next cutting could not even be imagined. This final uncut residue, with its finite magnitude to account for the size of ordinary bodies, was an atom. Although this argument from analogy cannot be said to be tenable, for many centuries it was the only one that prevented the atomic hypothesis from being chimerical. All the same, an elaborate theory was soon developed.

In order to explain nature's infinitude of forms, Leucippos postulated that the atoms were infinite both in number and in variety of shapes. A special reason for not limiting the number of shapes was his inability to find any particular shapes that seemed appropriate for atoms. Likewise he failed to discover any proper motions of the atoms; hence, he concluded that they could move in any direction. The celebrated example of the sun and the motes depicting atomic chaos is believed to have been given first by the early atomists although Lucretius' account[5] is the only one extant: "Of this truth, which I am telling, we have a representation and picture always going on before our eyes and present to us: observe whenever the rays are let in and pour the sunlight through the dark chambers of houses: you will see many minute bodies in many ways through the apparent void mingle in the midst of the light of the rays, and as in never-ending conflict skirmish and give battle combating in troops and never halting, driven about in frequent meetings and partings." Some moderns have taken this indefiniteness as an implication that chance was inherent in his system, because a similar postulate of a random distribution is basic in statistics to-day. But this was far from beng true. Indeed, Leucippos, was the first to enunciate what Leibniz later emphasized as his *raison suffisant* or "there is a sufficient reason for every happening" and what Swann[6] recently called the "intelligent design" of the universe. Of course, the atoms jostled one another in their motions so that entanglements inevitably ensued on account of the variety of shapes. These clusters became larger and larger until ordinary matter resulted. In these formations three ill-defined possibilities were recognized as is illustrated by the figures of a square and a parallelogram in Fig. 1.

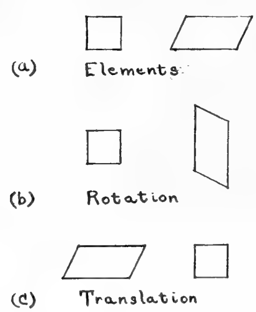


Fig. 1.—For explanation see text.

[5] *Lucretius—On the nature of things*—translated by H. A. J. Munroe (1919) Book II.
[6] *The architecture of the universe*—W. F. G. Swann (1934) 401.

That such arrangements were highly fanciful is not to be denied. And yet, what about the hooked atoms of John Bernoulli and of the nineteenth-century chemists? Certainly all these elaborate theories of the structure of matter were presumptuous before the atomic hypothesis had met an *experimentum crucis* such as Einstein's equation for Brownian movements later offered.

Greek speculation became rampant in the subsequent history of atomism. Democritos of Abdera (c.460–370 B.C.), changing only a few minor matters, discussed in even greater detail the various types of arrangement so that he was finally able to give an explanation of sensation itself on this basis. And then using this as the foundation for a theory of knowledge and of ethics, as well as for the usual cosmology, he formulated a complete philosophic system. The distinctive physical feature of his type of atom was its unrestricted size, e.g., an atom could be as large as a house. In other words, there was an infinity of both shapes and sizes. From our viewpoint, however, the significance of Democritos' work can be judged best from two statements of his own. In the first place he reäffirmed the dictum of Melissos that "nothing is created out of the non-existent, or is destroyed into the non-existent." This is the gist of our modern principle of continuity, which has so many special forms, e.g., Kirchhoff's first law for an electric circuit. He stressed also that absolute determinism that follows logically any mechanical representation of the universe. "By necessity are foreordained all things that are and are to come." Any failure to trace the mechanical process results merely from ignorance. So he noted the possibility of a plurality of causes for a final state that alone is observed, e.g., here is the earth, what is its origin? But the ethical implications of his system already foreshadowed the approaching abandonment of the study of natural philosophy for its own sake—an ironical turn, for the "laughing philosopher" scorned utilitarian motives.

Greek atomism culminated in the work of Epicuros[7] of Samos (c. 341–270 B.C.), whose system has been carefully preserved in that immortal poem of Titus Carus Lucretius (c.98 or 95–55 B.C.), *De Rerum Natura*. Once more the reality of sensation was made the *sine qua non* of all knowledge. Indeed, empiricism was extended to a rejection of the infinite divisibility of matter. For the strength of materials did not seem to warrant the inevitable destruction that the constant breaking up of matter would cause. Epicuros proceeded to modify the atomic theory by assigning another property to the atom

[7] *The Greek atomists and Epicurus*—Cyril Bailey (1928).

—weight. We are to understand this, not as technically differentiated from inertia, but as vulgarly used for either. It was this weight which caused the atoms to move, not promiscuously throughout space, but all downward with the same speed. Yet, how could such a rain of atoms bring about the clustering entanglements? Occasional swervings had to be allowed so that collisions could take place. As a matter of fact, even upward motion could be realized by the squeezing of a light atom in contact with two heavy swerving ones (cf. Fig. 2). It

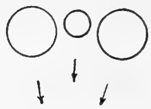


Fig. 2.—For explanation see text.

is interesting to note that the speed of the atoms was supposed to be invariable. (This same assumption was made by Rudolph Clausius [1822–1888] in his kinetic theory, notwithstanding his recognition of its invalidity owing to collisions.) The notion of swervings, for which no reason was assigned, appears strangely arbitrary in a deterministic system. And yet, it was not an accidental choice. On the contrary, it was a deliberate attempt to permit freedom of the will in a system which had only a single hypothesis—the atom. And again we see the increasing influence of ethical ideals upon physical ideas. This relationship has never been severed although it is most common now in an inverted form, i.e., physical laws are sometimes regarded as cabalistic expressions of ethical principles. One recalls the popular philosophies of freedom which found support in the spontaneity of Bohr's electronic transitions—not to mention the mysticism[8] concomitant to Heisenberg's "uncertainty principle." Truly the relation between swerving atoms and wavering ethics is as suggestive to-day as when it allowed for Epicurean delights and for Lucretius' suicide.

Epicuros retained Leucippos' view that atoms did not lose their speed while in an entangled array. He explained the usual varying velocities by a preponderance of atoms in a certain direction of motion—a sort of balancing effect. For example, a body, consisting of 100 atoms all moving to the left momentarily and of 50 more all moving to the right momentarily, would move to the left with less speed than that common to the atoms. (It is difficult to apprehend this in our modern terms of force and inertia.) The possibility of rest resulting from a combination of moving particles is illustrated by

[8] *The nature of the physical world*—A. S. EDDINGTON (1928) 332. *The mysterious universe*—JAMES JEANS (1930) 31.

Lucretius' classical picture[5] as follows: "Thus often the woolly flocks as they crop the glad pastures on a hill, creep on whither the grass jewelled with fresh dew summons and invites each, and the lambs fed to the full gambol and playfully butt; all which objects appear to us from a distance to be blended together and to rest like a white spot on a green hill." There is still another fact which should be added to our description of Epicuros' atomism. He rejected Democritos' atoms of unlimited size. Furthermore, he postulated only a finite number of shapes for a given magnitude. Just as an atom was conceived to be the physical limit of divisibility, so, too, a surface was to be regarded as having a minimum part that could not be divided. And all surfaces had to consist of an integral number of such parts. To use Brieger's illustration, suppose the minimum part is a square. Now consider an atom made up of three cubes, of which each face is such a minimum square. Then there are only two possible shapes for this type of atom (cf. Fig. 3). (The condition is that each surface

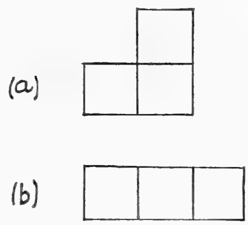


Fig. 3.—For explanation see text.

of the atom must consist of an integral number of these squares.) Thus the limit of size itself sets a limit to the number of shapes. A final remark, the atoms of air were looked upon as being very loosely arranged; those of a liquid were regarded as more permanently restrained by an outside shell; those of a solid were believed to be closely interlocked. Our modern view would show a similar picture.

The atomism of the Greeks can hardly be said to be like that of the present even though certain conclusions appear identical. Indeed, we have given the above description to emphasize the fact that any such notion can be the result only of gross misconceptions. We are impressed, however, by the similarity between the operation of the human mind then and now. The same thought-mold is evidentally essential to any given theory, whether it is speculative or experiential in origin. For principles we deem peculiar to our modern scientific world are found to be the underlying hypotheses of Greek surmises. But what stands out unique in their view of nature is the grandeur

of the possibility of a unified explanation. This intellectual vision looms far above the shadowy horizons of Egypt, Chaldea and India. Again and again, their esthetic desire for a coherent whole asserted itself in philosophic systems, which we find puzzling without access to the scaffolding used in the constructions. But even to-day they tower above our own world to remind us that mankind is still in quest of unity.[9] Somehow the sober light following the flushed dawn of enthusiasm has revealed to us that metaphysics (μετά φυσικά) must always come *after physics* and that physics itself is not too amenable to a unified rationalization. But with many of the Greek hypotheses coloring our scientific fabric and with many of their threads yet to be unentangled we, too, seek to weave a universal design.

[9] *A survey of physics*—MAX PLANCK (*The unity of the physical universe* is the title of one of a collection of essays).

PHYSICS.—*Pressure-volume-temperature relations for six oils.*[1] RICHARD B. DOW, Research Laboratory of Physics, Harvard University. (Communicated by MAYO D. HERSEY.)

The physical properties of lubricating oils at high hydrostatic pressures have not been extensively studied. The viscosity of oils at high hydrostatic pressures has, however, been studied[2,3,4] at this laboratory and is being further investigated for it has long been recognized that viscosity is the significant physical property in thick film lubrication. The study of the thermodynamic properties of oils under pressure has been neglected except for the pressure-volume data that were obtained by Hyde[5] at one temperature. It is well known that the pressure-volume relations must be observed at more than one temperature in order that a thermodynamic analysis be complete.

The present technical advances in the production of mineral oils wherein considerable attention is devoted to the chemical properties of crudes other than those of a paraffinic base, and the increasing use of the method of dimensional analysis[6] in predicting physical relations that may depend on the properties of lubricants, make desir-

[1] This investigation has been financed by the Special Research Committee on Lubrication, American Society of Mechanical Engineers, as a part of their research program and was carried out in this laboratory with Professor P. W. Bridgman's high pressure apparatus. It is a pleasure to acknowledge his interest and kindness as well as the coöperation of Professor Theodore Lyman. Received August 10, 1934.

[2] M. D. HERSEY. This JOURNAL **6**: 525. 1916.

[3] M. D. HERSEY and H. SHORE. Mech. Eng. **50**: 221. 1928.

[4] R. V. KLEINSCHMIDT. Trans. A.S.M.E., APM-50-4. 1928.

[5] J. H. HYDE. Proc. Roy. Soc. A **97**: 240. 1920.

[6] M. D. HERSEY. This JOURNAL **23**: 297. 1933. Also Proc. World Petroleum Congress, London: 1934, p. 389.

able at this time a survey of some of the thermal functions of typical oils that are used in lubrication. While it is realized that a complete understanding of these thermal properties, such as one obtains for a pure, comparatively simple liquid, will probably never be attained, it is believed that it would be of interest to have some of them recorded and a comparison made with the corresponding properties of simpler liquids.

This investigation presents the pressure-volume-temperature data obtained on six oils up to hydrostatic pressures approaching apparent solidification at temperatures of 25°, 40°, and 75°C, and includes a discussion of the thermodynamic characteristics[7] which are derivable from the fundamental data.

THE METHOD AND APPARATUS

The isothermals at the three temperatures were determined by the sylphon method of Bridgman.[8] A liquid is sealed within the sylphon to which is attached a slide-wire and the sylphon, mounted in a suitable holder, is placed within a pressure chamber of conventional type.[9] When hydrostatic pressure is applied the change of volume is proportional to the change of resistance of the slide-wire which is part of an external potentiometer circuit.[10] Once the constants and the corrections of the sylphon are known, it is a simple matter to compute the relative volumes from the corresponding resistance measurements. The pressure is computed from the change of resistance of a manganin coil, and the temperature is the corrected thermometer reading of a thermostatically controlled water bath.

DESCRIPTION AND CHOICE OF OILS

The six oils used for this study were from various sources. The four light mineral oils of approximately equal viscosity at 30°C, but from different crudes, were obtained from the Atlantic Refining Company through courtesy of Dr. J. Bennett Hill. The following characteristics were furnished by Dr. Hill (Table 1).

The Pennsylvania oil was a distillate from a crude of the same name which had been percolated through clay to obtain the final color. The Mid-Continent was made from a distillate from a mixed base

[7] The thermodynamic characteristics of a substance, whose state is defined by t and p, are completely determined when the following are known: (1) $(\partial v/\partial t)_p$ and $(\partial v/\partial p)_t$ over an extended range of t and p; (2) v at an arbitrary t and p within the range of (1); and (3) C_p along some line not an isothermal, t is the thermodynamic temperature.

[8] P. W. Bridgman. Proc. Amer. Acad. **66**: 185. 1931.

[9] P. W. Bridgman. *The physics of high pressure*, Chap. 2: Macmillan. 1931.

[10] P. W. Bridgman. Proc. Amer. Acad. **56**: 64. 1921.

TABLE 1.—PHYSICAL CONSTANTS OF OILS[11]

Type of Oil	Gr. A.P.I. 60°F	Saybolt Univ. Vis. 100°F	Saybolt Univ. Vis. 210°F	V.G.C.	Flash °F
Pennsylvania	31.1	145	42.0	0.818	385
Mid-Continent	29.2	137	40.2	0.832	375
Renown Engine	25.7	145	39.1	0.856	375
Gulf Coast	23.7	130	38.0	0.872	320

Texas crude by pressing, redistilling, acid treating and percolating through clay. The Gulf Coast was a distillate from a Texas crude, acid treated and neutralized.

The remaining samples were fixed oils, lard and sperm, having somewhat greater viscosity at 30°C. The lard oil was a clear, translucent product from a local source while the sperm oil was furnished by Mayo D. Hersey from his collection of oils tested by Hyde[5] at the National Physical Laboratory some fourteen years earlier.

It is well known that the principal constituents of Pennsylvania oil are the paraffines, C_nH_{n+2}, and that the Gulf Coast crudes consist mainly of the napthenes or cycloparaffines, C_nH_{2n}. The fatty oils are composed of glycerides and a mixture of acids belonging to the series $C_nH_{2n+1} \cdot COOH$.

It would appear that the above choice of oils is such that any significant structural features related to volume would be exhibited at high pressures. This reasoning, more or less speculative, is based on the numerous results that Bridgman[8] has obtained with pure liquids. For example, he has shown that the liquids of the methane series have considerably different compressibilities from those of the benzene series. Hyde's work showed that the compressibilities of oils of wide difference in viscosity at 40°C differ slightly, but his results were insufficient to give all the information one would like and, also, his choice of mineral oils was not the one best suited to exhibit the relation between the structural features and the molecular volume of the different basic crudes when subjected to high pressures.

COMPUTATION OF DATA AND OTHER FUNDAMENTAL QUANTITIES

Volumes.—The fundamental data consist of the volumes of oils at definite pressures and temperatures. These data are collected in Table 2. All further information of thermodynamic interest can be

[11] The abbreviations used in Table 1 have the following meanings: *Gr. A.P.I.*, The American Petroleum Institute's specific gravity scale; *Saybolt Univ. Vis.*, the viscosity as indicated by the Saybolt Universal Viscosimeter; *V.G.C.*, the viscosity-gravity constant (J. B. HILL and H. B. COATS, Ind. Eng. Chem. **20**: 641. 1928) to indicate the degree of paraffinicity; *Flash*, the A.S.T.M. flash point or temperature at which the vapor of the oil ignites.

TABLE 2.—RELATIVE VOLUMES

Pressure kg/cm²	25°	40°	75°	25°	40°	75°
	Pennsylvania Oil (ρ_{40}=0.8524)			Mid-Continent Oil (ρ_{40}=0.8663)		
1	0.9901	1.0000	1.0178	0.9894	1.0000	1.0197
50	0.9869	0.9966		0.9861	0.9964	
100	0.9839	0.9934		0.9832	0.9930	
250	0.9752	0.9841	1.0040	0.9746	0.9838	1.0038
500	0.9632	0.9711	0.9908	0.9625	0.9704	0.9895
750	0.9529	0.9599	0.9786	0.9526	0.9594	0.9768
1000	0.9440	0.9504	0.9672	0.9441	0.9497	0.9659
1250		0.9418	0.9572		0.9412	0.9561
1500		0.9340	0.9485		0.9336	0.9476
2000		0.9196	0.9330		0.9199	0.9329
2500			0.9196			0.9204
3000			0.9082			0.9094
3500			0.8983			0.8995
4000			0.8891			0.8900
	Gulf Coast Oil (ρ_{40}=0.8937)			Renown Engine Oil (ρ_{40}=0.8842)		
1	0.9902	1.0000	1.0182	0.9905	1.0000	1.0177
50	0.9868	0.9966		0.9874	0.9967	
100	0.9838	0.9935		0.9845	0.9936	
250	0.9757	0.9845	1.0041	0.9761	0.9847	1.0037
500	0.9643	0.9714	0.9909	0.9642	0.9723	0.9907
750	0.9544	0.9605	0.9788	0.9544	0.9615	0.9791
1000	0.9457	0.9512	0.9678	0.9461	0.9522	0.9687
1250		0.9431	0.9578		0.9437	0.9589
1500		0.9354	0.9492		0.9359	0.9504
2000		0.9218	0.9342		0.9219	0.9352
2500			0.9216			0.9226
3000			0.9106			0.9115
3500			0.9010			0.9018
4000			0.8925			0.8931
	Lard Oil (ρ_{40}=0.9009)			Sperm Oil (ρ_{40}=0.8945)		
1	0.9902	1.0000	1.0190	0.9894	1.0000	1.0227
50	0.9872	0.9965		0.9864	0.9966	
100	0.9844	0.9936		0.9835	0.9934	
200				0.9781	0.9876	1.0099
250	0.9763	0.9850	1.0051			
300				0.9730	0.9818	
400				0.9685	0.9768	
500	0.9647	0.9721	0.9921		0.9722	0.9925
750	0.9550	0.9615	0.9800		0.9618	0.9794
1000	0.9461	0.9523	0.9697		0.9525	0.9684
1250	0.9377	0.9440	0.9603		0.9437	0.9591
1500	0.9299	0.9366	0.9522			0.9510
2000		0.9229	0.9374			0.9368
2500		0.9111	0.9240			0.9241
3000			0.9120			0.9127
3500			0.9016			0.9021
4000			0.8927			0.8926

computed from them, assuming the specific heat at constant pressure for atmospheric pressure to be known. The calculations were made in the following manner: The equivalent slide-wire resistances were plotted against pressure on large graph paper for the temperatures 25°, 40°, and 75°C, and smooth curves drawn. The changes of volume were directly computed from the corrected changes of resistance, read off at even pressure intervals, by applying the various conversion and correction formulae.

For these computations and those which follow, the nomenclature adopted by Bridgman[12] has been followed. The actual losses of volume in cm^3 were computed from the volume at atmospheric pressure at 40°C taken as unity. This method of expressing the data aids in a quicker understanding of Table 2 and simplifies the calculation of thermal quantities; thus, in computing the compressibility, $(\partial v/\partial p)_t$ was used instead of the more common form $(1/v_0)\ (\partial v/\partial p)_t$. In Table 2, ρ_{40} denotes the density at 40°C in grams/cm^3.

The densities at atmospheric pressure were determined at three temperatures by the use of a specific gravity bottle, for two reasons, instead of relying on the sylphon measurements alone. First, the measurement of the volume of the sylphon at atmospheric pressure and 75° could not be made because of danger of the sylphon expanding beyond a safe limit. This made it necessary that the thermal expansion between 40° and 75° be known in order for the pressure-volume data at the highest temperature to start at atmospheric pressure without extrapolation. Consequently, the volumes in Table 2 at atmospheric pressure and 75° are those volumes determined by specific gravity measurements. Second, knowing the expansion between 25° and 40° as the result of an independent measurement, the expansion between the same two temperatures as found by the sylphon method could be checked. The two determinations for thermal expansion differed by not more than 0.2 per cent.

Compressibility, Thermal Expansion, Specific Heat.—The compressibility was determined from the pressure-volume curves at constant temperature as the average compressibility over small ranges of the curves where departures from linearity were not important. The thermal expansion was similarly derived. The variation with pressure of the specific heat at constant pressure, might be calculated from the data given, but it is believed that nothing is to be gained from it

[12] P. W. Bridgman. Proc. Amer. Acad. **49**: 100. 1913; and also Chap. V of *The physics of high pressure.*

for the time being. Twelve pure liquids examined in this respect by Bridgman[12] showed such a bewildering variety of curves that he considered speculation hopeless as to the cause of all the variations.

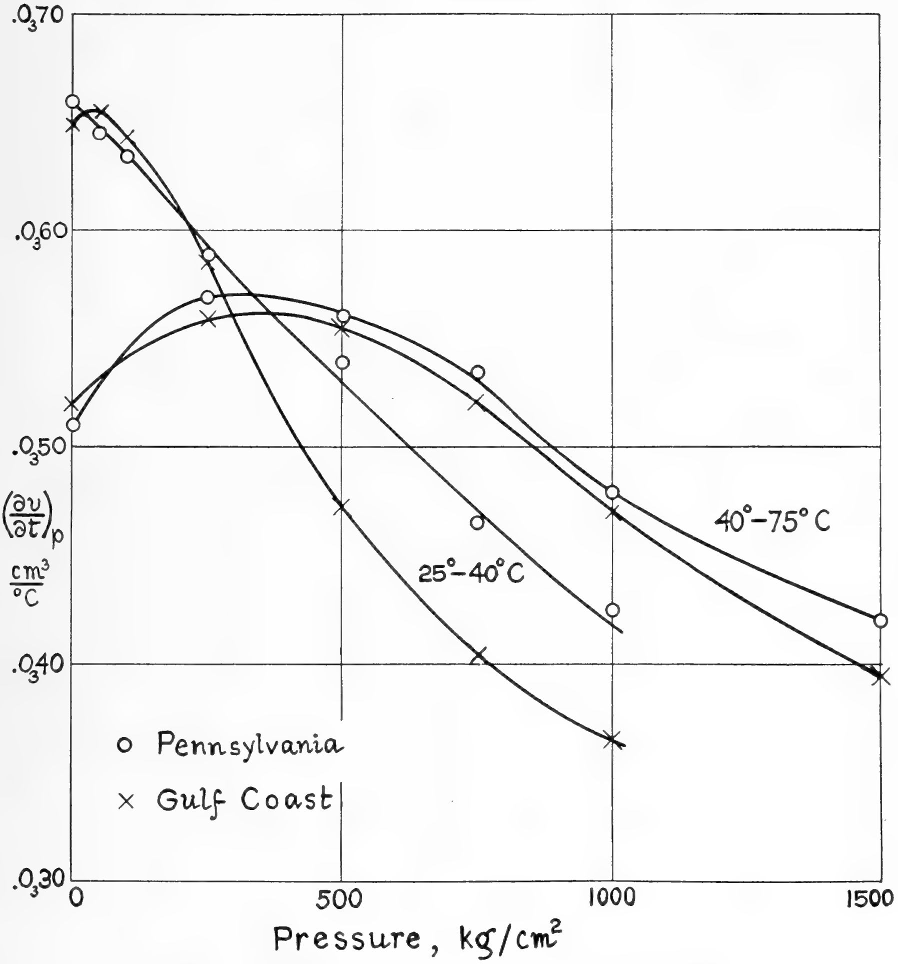


Fig. 1.—Average thermal expansion against pressure.

Thermodynamic Functions.—The functions to be considered are: the *pressure coefficient*, i.e., coefficient of pressure change with temperature at constant volume, *work of compression, heat of compression,* and *change in internal energy.* If the *pressure coefficient* $(\partial p/\partial t)_v$ is constant along some line of constant volume which cuts three isothermals at temperatures t_1, t_2, and t_3, the ratio of pressure differences $(p_3 - p_2)/(p_2 - p_1)$, where in each case, the pressure at the same volume is read off its respective isothermal, is equal to the ratio $(t_3 - t_2)/$

(t_2-t_1). The pressure coefficient will be discussed in this sense. The work of isothermal compression was calculated by the integral $\Delta W = \int -p(\partial v/\partial p)_t dp$, and the corresponding heat of compression by $\Delta Q = \int t(\partial v/\partial t)_p dp$; the integration was performed with sufficient accuracy by plotting the functions against pressure and then integrating with a planimeter. The change in internal energy is given by the first law of thermodynamics as $\Delta E = -\Delta Q + \Delta W$ where $\Delta E = E - E_0$, E_0 being the internal energy at atmospheric pressure.

DISCUSSION OF RESULTS

A complete discussion of the thermal properties that can be derived from Table 2 would mean considerable computation which does not seem justified at present. Inasmuch as one can derive from the table any function that particularly interests him, a considerable part of the following discussion will be limited to general aspects.

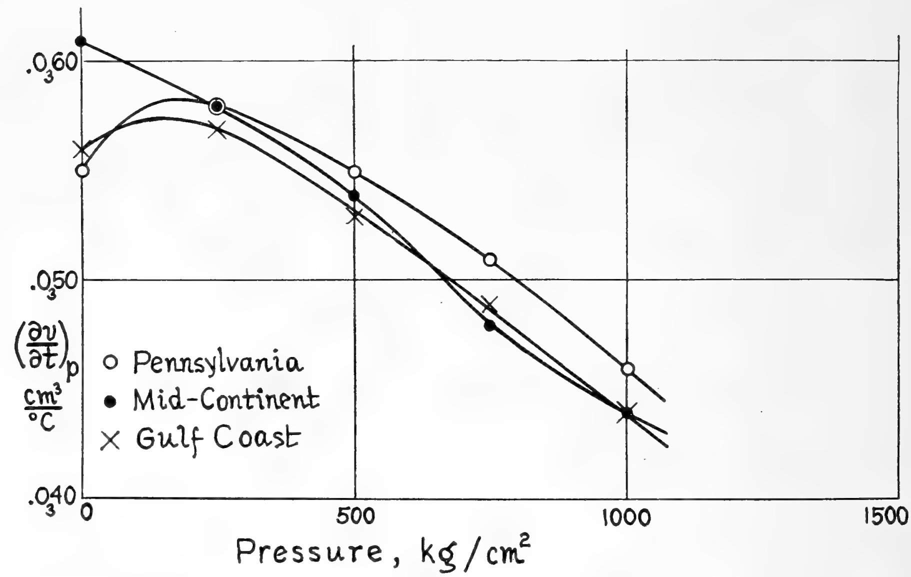


Fig. 2.—Average thermal expansion 25°–75°C against pressure.

Relative Volume, Compressibility, and Thermal Expansion.—A brief inspection of Table 2 shows that the relative volumes do not vary greatly for the six oils. Consequently, the compressibilities and thermal expansions of the different oils are not greatly different.

On computing the compressibility for the Pennsylvania sample at 40°, it was found that the compressibility at 1000 kg/cm² was 35.5×10^{-6}, or about one-half its initial value of 68×10^{-6}. This places the compressibility of the oil at approximately the middle of the range

from the high value of n-pentane to the low value of glycerine. This conclusion applies equally well for the remaining oils. As regards the effect of temperature on the compressibility, the six oils behave as normal liquids in that the compressibility increases slowly with temperature at constant pressure.

For most substances the thermal expansion $(1/v_0)(\partial v/\partial t)_p$ increases with temperature; $(\partial^2 v/\partial t^2)_p$ is positive and decreases as the pressure is raised. The behavior of the oils is not normal in this respect at atmospheric pressure; the volume increases with temperature more rapidly in the lower range from 25° to 40°. This means that the second derivative is negative.

At the higher pressures and the lower temperature interval, the average expansion decreases with increase of pressure for all oils except the Gulf Coast which shows an increase in the range from 1 to 50 kg/cm² and then a decrease at higher pressures. Figure 1 reveals the order of magnitude and the variation of the expansion for two oils.

For the temperature interval 40° to 75°, the thermal expansion in every case changes anomalously with pressure; increasing with pressure to 300 kg/cm², then decreasing for the rest of the range. This effect is also illustrated for two of the oils in Figure 1. The reversal of sign of $\partial^2 v/\partial t \partial p$ is interesting for this is not observed for pure liquids.[12] Since the coefficient is much smaller to begin with in this interval of temperature, the curves of expansion against pressure for both intervals of temperature cross, giving the same expansion at a certain pressure. This pressure is also close to 300 kg/cm².

Finally, the average thermal expansion remains to be considered over the entire range between 25° and 75°. The results of the computation can be seen by examining the pressure curves for three of the oils in Figure 2. The expansion in this range of temperature is anomalous for Pennsylvania and Gulf Coast oils.

There seems little likelihood for an adequate explanation of the complications in the thermal expansion at high pressures. Bridgman[12] pointed out in 1913 the need for considering the shapes and orientations of the molecules and their assemblages in order to get even a simple picture of some of the complicated effects of expansion in pure liquids at high pressures. Undoubtedly, the effects of shape and orientation play important parts in the complications, but the molecular groups or aggregates are so complex in any oil that the significance of structure is obscured. For example, one would expect that the expansion of an oil of naphthenic base would be more com-

plicated than the expansion of one of paraffinic base, because in the latter the chain compounds should show less tendency for haphazard arrangement under pressure and the regularity of orientation should increase with pressure. For the oil of ring-type molecules, the resulting change in orientation with change of pressure would be expected to be less regular because of the less orderly interlocking between groups of molecules. However, these speculations are not substantiated by the data of this paper. There seems to be no clear effect of structure on the thermal expansion. While the pressure-expansion curve for the interval 25°–40° appears to have a more uniform slope in the case of the Pennsylvania oil than for the Gulf Coast oil, the same curve if drawn for lard oil reveals a complexity comparable to that observed for the Gulf Coast oil. The expansions for paraffinic and fatty oils have smaller changes with pressure than the expansions for naphthenic and mixed-base oils but the differences are small.

Work and Heat of Compression; Change in Internal Energy.—The work and heat of compression were calculated for the Pennsylvania sample and curves of these functions against pressure were examined. The curves are similar in shape to those for pure liquids[12]. The curve for the work done in compressing the oil starts out in a normal way as the pressure is increased and the work done in the first 2000 kg/cm^2 is about half that of a normal liquid. The heat of compression increases uniformly with the pressure and amounts to about 1.5 kg.m. against 3 or 4 kg.m. for pure liquids.

The change in internal energy of these oils is small because of the limitation of the pressure range imposed by the relatively low freezing pressures. The ΔQ and ΔW curves are normal in the pressure range which is limited to 2000 kg/cm^2 at 40°, and the ΔE curve varies in such a way that ΔE decreases uniformly with increase of pressure under the same conditions.

The ratio $\Delta E/\Delta W$ is of interest because it offers a means of estimating the work done by the attractive forces between the molecules

TABLE 3.—RELATIVE VALUES OF THE RATIO $\Delta E/\Delta W$ AT 40°C

Liquid	$\frac{(\Delta E/\Delta W)_{500}}{(\Delta E/\Delta W)_{1000}}$	$\frac{(\Delta E/\Delta W)_{1000}}{(\Delta E/\Delta W)_{2000}}$
Acetone	1.92	1.84
Pennsylvania oil	1.84	1.50
Ethyl alcohol	1.65	1.84
Carbon disulphide	1.62	1.83
Ether		1.19

when the substance is compressed. This ratio has been computed at several pressures for the Pennsylvania oil and a few pure liquids. The results are expressed in Table 3 as the change of $\Delta E/\Delta W$ produced by pressure.

Pressure Coefficient.—Bridgman[8] has proved that $(\partial p/\partial t)_v$ cannot be a function of volume alone as had often been considered to be the case. By evaluating the ratio of pressure differences as already explained, he found that instead of the ratio equaling 0.90, which should be the case if the coefficient is a function of volume at 0°, 50°, and 90°, it varied considerably with all the pure liquids at low pressures. At higher pressures, the departures from 0.90 were much greater.

In the following table the ratio $(p_3-p_2)/(p_2-p_1)$ is listed for five oils. The range of volume is unavoidably small. The pressures p_1, p_2, p_3, for different relative volumes were read off the isotherms for 25°, 40°, and 75°, respectively. The ratio $(p_3-p_2)/(p_2-p_1)$ should thus equal 2.33 for all volumes if the pressure coefficient is a function of volume alone.

TABLE 4.—Evaluation of the Ratio $(p_3-p_2)/(p_2-p_1)$

Oil	Rel. Vol.	Pressure Ratio	Rel. Vol.	Pressure Ratio	Rel. Vol.	Pressure Ratio
Pennsylvania	.990	2.42	.980	2.58	.945	2.65
Mid-continent	.988	2.50	.980	2.09	.945	2.72
Gulf Coast	.990	2.21	.980	2.40	.945	2.36
Renown	.992	2.16	.980	2.33	.945	2.53
Lard	.991	2.50	.980	2.45	.945	2.69
Lard	.920	1.76				

The departures of the Pennsylvania and Renown oils from 2.33 increase with pressure. The Mid-continent and lard oils show more irregularity.

Remarks on Sperm Oil.—The change in density of sperm oil with pressure has been computed by Hyde.[5] As the oil used in the present work was a sample of the same oil that had been tested by Hyde, it was hoped that a means of comparison of the two investigations would be had. The density at atmospheric pressure given by Hyde was over 3 per cent less than the value found here, being 0.866 against 0.895. This is not surprising when one considers that the oil has probably oxidized during the interval of fourteen years. It is interesting, however, to observe that when the pressure-density curves are drawn for both tests, the slopes are approximately equal, hence the compressibilities computed from them differ only by the initial value taken for the density.

CONCLUSION

The relative volumes at three temperatures have been recorded at pressures up to those approaching the apparent solidifying pressures for six oils of different composition. It has been found that the volumes and the derived thermal properties, in general, are similar for all the oils. But of the variations determined the thermal expansion varies the most with pressure and temperature, and in a manner contrary to its behavior for pure liquids at low pressures.

It would seem desirable to obtain more detailed information about the thermal expansion as well as data on the viscosity and thermal conductivity at high pressures. In order to study the thermal effects at high pressures in more detail, one of the mineral oils has been fractionated and the present investigation is being continued for some of the individual cuts from this oil.

CHEMISTRY.—*p-Fluorophenacyl alcohol and some of its esters.*[1]

Raymond M. Hann and J. P. Wetherill, Washington, D.C. (Communicated by Frederick H. Goldman.)

Judefind and Reid,[2] in their study of p-halegon, substituted phenacyl bromides as reagents for the separation and identification of acids, have indicated the superiority of the halogen compounds over the unsubstituted phenacyl bromide because of the lower solubility of the resulting halogenated esters.

A search of the available literature indicates that a p-fluorophenacyl halide has not been studied in this connection, and the purpose of the present study was to isolate a suitable fluorine compound and test its applicability as a reagent. The study has revealed that p-fluoro-ω-chloroacetophenone may be readily prepared in large yield by the Friedel Crafts' reaction. The fluorophenacyl esters so far obtained possess no advantage over other already described p-halogen esters, and the original cost of fluorobenzene mitigates against their preparation.

Incidental to the preparation of the esters, p-fluorophenacyl alcohol (also known as p-fluorobenzoyl carbinol) has been obtained to complete the list of possible p-halogenated phenacyl alcohols.

EXPERIMENTAL

p-Fluorophenacyl chloride (*ω-chloro-p-fluoroacetophenone*).—To a constantly stirred suspension of 75 g. of anhydrous aluminum chloride

[1] Received October 23, 1934.

[2] Jour. Amer. Chem. Soc., **42**: 1043. 1920.

in 150 cc. of carbon disulfide and 48 g. of fluorobenzene at room temperature, 56 g. of chloroacetyl chloride were added dropwise during the course of 1 hour. The reaction mixture was then gently refluxed for six hours, during which time it assumed a yellow color, hydrochloric acid gas was evolved, and a somewhat darker colored heavy oil separated. It was cooled and poured into a suspension of 90 g. of concentrated sulfuric acid in finely crushed ice, the resulting crystalline precipitate filtered off, and the residual carbon disulfide separated and evaporated to yield a further crystalline deposit. The combined solids were recrystallized from two parts of 95 per cent alcohol, the substituted phenacyl chloride obtained weighing 68.4 g. (79 per cent, based on fluorobenzene). Appreciation is expressed to H. P. Newton for assistance in carrying out this synthesis.

p-Fluorophenacyl chloride crystallizes in brilliant, glistening large plates, melting at 48°C. to a clear oil without decomposition. Its vapor has an intense lachrymatory action, and in warm weather it is volatile enough to cause severe discomfort when handled in ordinary manipulations.

Anal. Calcd. for C_8H_6OClF: Cl, 20.6. Found, 20.5.

p-Fluorophenacyl acetate.—A solution of 4 g. of p-fluorophenacyl chloride, 3 g. of fused sodium acetate and 0.5 cc. glacial acetic acid in a mixture of 5 cc. water and 20 cc. 95 per cent alcohol was refluxed for 1 hour. On cooling, alcohol in small amounts was added to prevent clouding, and after several days the acetate crystallized. Yield 3.9 g. (87 per cent).

p-Fluorophenacyl acetate crystallizes in glistening colorless scales from 60 per cent alcohol. It melts at about the same temperature as the chloride; namely, at 48.5° to 49.0°, but upon admixture with the halogen compound it liquefied.

Anal. Calcd. for $C_{10}H_9O_3F$: F, 9.7. Found, 9.5. Saponification equivalent 196.1. Found, 194.2.

p-Fluorophenacyl alcohol.—A suspension of 1 g. of p-fluorophenacyl acetate and 0.6 g. of washed barium carbonate in 50 cc. of water was refluxed for 1 hour; the acetate, an oil initially, gradually disappeared. The warm reaction mixture was filtered through char, and upon cooling the alcohol crystallized in colorless elongated plates melting at 114°C. in a yield of 0.7 g. (90 per cent). The melting point was unchanged upon recrystallization from 10 cc. of hot water. The acetate was regenerated by treatment with acetic anhydride.

Anal. Calcd. for $C_8H_7O_2F$: F, 12.3 Found, 12.1.

p-Fluorophenacyl nitrobenzoates.—A solution of 1.2 g. of nitro-

benzoic acid, 5.9 cc. of 1N. sodium hydroxide and 1 g. of p-fluorophenacyl chloride in 20 cc. of 95 per cent alcohol was refluxed for 1 hour and the reaction product obtained on cooling or by precipitation with small amounts of water. The esters may be readily recrystallized from 95 per cent alcohol.

p-Fluorophenacyl-o-nitrobenzoate crystallizes in very slightly yellow microscopic needles, melting at 74.5°C. to a clear oil.

Anal. Calcd. for $C_{15}H_{10}O_5NF$: nitrogen, 4.6. Found, 4.5.

p-Fluorophenacyl-m-nitrobenzoate separates in colorless glistening needles, melting at 105°C. to a clear colorless oil.

Anal. Calcd. for $C_{15}H_{10}O_5NF$: nitrogen, 4.6. Found, 4.5.

p-Fluorophenacyl-p-nitrobenzoate crystallizes in slightly yellow needles, melting at 134°C. to a clear oil.

Anal. Calcd. for $C_{15}H_{10}O_5NF$: nitrogen, 4.6. Found, 4.7.

SUMMARY

p-Fluorophenacyl alcohol and several of its esters have been prepared and described.

PHARMACOLOGY.—*The nitrite-thiosulphate combination as a remedy for cyanide poisoning in sheep.*[1] H. BUNYEA, J. F. COUCH, and A. B. CLAWSON, Bureau of Animal Industry.

In a former paper[2] the results of experiments with remedies for cyanide poisoning in sheep and cattle were reported. It was found that, of the remedies tried, a combination of sodium nitrite and sodium thiosulphate[3] was the most effective for cattle. The combination was not used on sheep at that time, but the results of the cattle experiments left little doubt that it would also prove to be the most effective remedy in the case of poisoned sheep.

The experimental methods used were the same as those already reported[2] and do not need extended repetition here. The cyanide was administered *per os* as potassium cyanide solution, freshly prepared, and the remedies were injected intraperitoneally, using 10 per cent solutions for the smaller doses and 20 per cent for the larger.

The results are given in Table I. Twenty-two experiments were performed with 18 animals of which 13 died. The doses were varied beginning with 2 m.l.d. calculated according to the figure previously reported for the m.l.d. (2.315 mg. per kg.), and rising gradually to 3.5 m.l.d. Table 2 is an analysis of these data and shows the effectiveness of the remedy against the various doses.

[1] Received November 1, 1934.

[2] This JOURNAL **24**: 369–395. 1934.

[3] This remedy was first suggested by E. Hug., C.r.Soc. Biol. **114**: 711–714. 1933.

TABLE 1.—NITRITE-THIOSULPHATE AS A REMEDY FOR CYANIDE POISONING IN SHEEP

Date	Sheep	Weight	Dose	Time from drench— to first symptoms	to collapse	to giving remedy	Remedy Sodium nitrite	Sodium thiosulphate	Effect
1934	No.	kg.	m.l.d.	min.	min.	min.	g.	g.	
May 8	1111	49.9	2	1	2.5	5.5	1	1	Survived
9	1113	50.8	2.25	1	1.5	2.5	1	2	Survived
8	1244	43.5	2.5		1.5	3	1	2	Died
9	1111	49.9	2.5	0.5	2	4	1	3	Survived
8	1113	50.8	2.5		1	2	1	2	Survived
15	1111	49.9	2.75	0.5	1.5	2.5	1	3	Survived
15	1113	50.8	2.75	1	1.5	2	1	3	Survived
23	1465	29.9	2.75	1	1.25	6	1	3	Died
23	1456	29.5	2.75	1	1	5.5	1	3	Died
23	1459	35.8	2.75	0.75	1.5	15	1	3	Survived
8	11730	38.1	3	1	1.5	3	1	2	Died
8	1241	34.5	3	1	1	2.5	1	2	Died
Aug. 30	1507	36.2	3	1	2	2	3	2	Died
30	102A	32.6	3	1	1.5	1.5	1	2	Died
30	1578	40.35	3	1.25	1.25	1.5	1	4	Died
31	1556	37.2	3	1	1.5	1.5	2	2	Survived
Sept. 11	1561	42.6	3	1.5	4	4.5	2	3	Died
11	1560	37.2	3	1	1.5	2	2	3	Died
11	1572	35.8	3.5	1.5	2	2	2	3	Survived
11	1487	39	3.5	1.5	2	2	2	3	Died
11	1479	41.2	3.5	0.5	1.5	1.5	2	4	Died
11	1499	39.9	3.5	1	2	2	2	4	Died

It is plain that, if administered promptly, the remedy is reasonably effective against 2.75 m.l.d. of cyanide in sheep as against 2 m.l.d. in cattle. Of 5 sheep that received this large dose, three survived and two died. In the latter cases the remedy was withheld until the animals were in the gasping stage and thus the test of the remedy was very severe. One of the sheep that survived, No. 1459 was not given the remedy until 15 minutes after the completion of the drench. This animal was unusually resistant to the cyanide and after exhibiting early symptoms began to improve instead of becoming progressively worse. This condition persisted for some 12 minutes during which

TABLE 2.—EFFECTIVENESS OF THE REMEDY AGAINST VARYING DOSES OF CYANIDE

Dose m.l.d.	Number of animals	Survived	Died	Per cent survival
3.5	4	1	3	25
3	8	1	7	12.5
2.75	5	3	2	60
2.5	3	2	1	66
2.25	1	1	0	100
2	1	1	0	100

time the sheep rose to his feet and remained standing a few seconds. He then began to stagger, went down on the belly and exhibited the usual train of symptoms shown by the other cases. Administration of the remedy was now withheld until the sheep appeared to be in a condition similar to that of the other sheep 3 to 4 minutes after drenching.

In our work on cyanide poisoning we have occasionally found resistant animals that show irregular behavior during the course of the sickness. Two other cases of similar behavior were encountered recently which will be reported in another paper of this series. Aside from these cases the course of the sickness with the poisoned animals was similar to that already described.

THE EFFECT OF AN INCREASED DOSE OF SODIUM NITRITE

Since little was known about the proper dose of sodium nitrite for sheep the question arose whether a dose larger than 1 gram might not be more effective. Nitrites are themselves quite toxic and there would be a dosage above which the remedy might itself cause or contribute to the death of the animal.

TABLE 3.—Toxicity of Sodium Nitrite Injected Intraperitoneally

Date 1934	Sheep No.	Weight kg.	Dose mg./kg.	Actual dose g.	Effect
Aug. 31	1471	31.7	47.3	1.5	Died
" 31	1479	41.2	48.8	2	Survived
" 30	1521	34.45	58	2	Died
" 31	1516	42.6	70.4[a]	3	Survived
" 31	1482	31.7	78.8	2.5	Died
" 31	1480	34.9	84.8	3	Survived
" 31	1490	41.7	95.9[a]	4	Died
" 30	1527	34.4	113.3	4	Died
" 30	1504	38.09	120.7	4	Died
" 30	1499	39.9	150.3	6	Survived
Sept. 5	1499	39.9	150.3	6	Survived
Aug. 30	1467	40.8	195.9	8	Died

[a] Plus 2g. of sodium thiosulphate.

As a preliminary measure several sheep were given varying doses of sodium nitrite intraperitoneally. The data are detailed in Table 3. It is apparent that the effect of sodium nitrite is quite variable since four of the animals poisoned survived doses larger than proved fatal with other sheep and one, No. 1499, on two occasions survived the second largest dose given although 6 sheep were killed by much

smaller doses and one died on one-third as much. Owing to the variability it was impossible to draw conclusions about the m.l.d. The symptoms exhibited by the sheep consisted of depression and accelerated respiration. In sheep No. 1521 the rate of respiration reached 148 per minute within 10 minutes after injecting the nitrite and in sheep No. 1504, 152 per minute. Two experiments were made to obtain evidence as to whether the simultaneous injection of sodium thiosulphate would influence the toxicity of sodium nitrite. In neither case was there any apparent antagonism between the two salts.

The experiments led to the conclusion that a one gram dose of sodium nitrite intraperitoneally is the safest for remedial use and two grams is the largest dose that should be administered and then only under exceptional circumstances.

There remained the possibility that in actual cyanide poisoning the toxic effect of the nitrite might be counteracted by the cyanide and warrant the use of larger doses of sodium nitrite. To test this possibility eight sheep were given 3 m.l.d. of potassium cyanide and 4 were given 3.5 m.l.d. by mouth and immediately upon collapsing were treated with varying doses of sodium nitrite combined with sodium thiosulphate. The results are summarized in Table 4.

TABLE 4.—Effect of Increased Doses of Sodium Nitrite

Dose m.l.d.	$NaNO_2$ g.	$Na_2S_2O_3$ g.	Number of animals	Survived	Died
3	1	2	3		3
3	1	4	1		1
3	2	2	1	1	
3	2	3	2		2
3	3	2	1		1
3.5	2	3	2	1	1
3.5	2	4	2		2

From these figures it is apparent that increasing the dose of sodium nitrite did not alter the final outcome of the poisoning.

SUMMARY

The combination of sodium nitrite and sodium thiosulphate protects with reasonable certainty against 2.75 m.l.d. of cyanide particularly when the remedy is administered promptly.

Increasing the dose of nitrite to 2 and 3 g. did not result in improvement while introducing an unfavorable element due to the toxicity of the nitrite itself.

Increasing the dose of thiosulphate may have resulted in some

improvement and does not, of itself, introduce another toxicity factor.

The nitrite-thiosulphate combination was definitely more effective with sheep than with cattle.

Doses of sodium nitrite above 95 mg. per kg. are likely to be fatal and above 50 mg. per kg. are dangerous. The safest therapeutic dose that can be recommended for cyanide poisoning is 1 g. intraperitoneally for a 75 to 90 pound (35 to 40 kg.) sheep and 2 g. is the largest dose that should be given.

PALEONTOLOGY.—Celliforma spirifer, *the fossil larval chambers of mining bees.*[1] ROLAND W. BROWN, U. S. Geological Survey. (Communicated by JOHN B. REESIDE, JR.)

The 1930 Smithsonian expedition, led by C. W. Gilmore to the Bridger Basin in southwestern Wyoming, brought back to the National Museum among its collection of fossils a handful of curious, solid objects (Fig. 3) that have remained unidentified. These specimens were found by George B. Pierce in surface material weathered from the lower strata of the fresh-water Bridger formation of upper Eocene age, about 6 miles southeast of Mountainview, Wyo., in sec. 18, T. 14 N., R. 14 W.

The natural size sketch (Fig. 3) illustrates several of the more perfect specimens. They average 2.7 centimeters in length by 1.2 centimeters in diameter. They are greenish gray to white in color, smooth, and round; but many are slightly flattened and bent like a bean; most show the effects of former breakage and partial collapse and now superficially resemble cracked but not disintegrated eggshells. The apex is a low dextral spiral of four or five turns making an inconspicuously scalloped and pitted groove. In some examples the apex is an almost flat spiral, in others the last turns form a narrow prominent blunt point.

Numerous sections disclosed no internal cellular structure or organic remains of any kind. The matrix of the unbroken specimens is calcite; that of the more or less broken specimens is calcite and greenish clay. It is clear that the calcite crystallized in a cavity, sometimes filling the cavity completely, sometimes leaving empty pockets to be filled or not with clay.

Speculation about these objects ranged from snake eggs to date seeds, on which latter probability they were referred to me for identification. A search of the literature and the seed collections, however,

[1] Published by permission of the Director, U. S. Geological Survey. Received October 30, 1934.

failed to develop any definite clues suggesting relationship to plants. Turning to animal fossils, I found that Scudder[2] had described and figured a mass of insect eggs under the name *Corydalites fecundum.* These eggs are minute, 2.6 millimeters long by 0.6 millimeter wide but, when enlarged to a size comparable with the Wyoming specimens, become somewhat like them. Nevertheless, the large size of the Wyoming specimens, it seems to me, effectively precludes their having been insect eggs.

The specimens compare best with material described and figured by Dall[3] from the "silex beds" of the Tampa formation (now regarded as of lower Miocene age) at Ballast Point, Tampa Bay, Fla. According to Dall, his Figure 4, Plate 24, which is almost identical with some Wyoming specimens, represents the burrow of a fossil limestone-boring bivalve mollusk, *Lithophaga nuda* Dall (his Fig. 7, Pl. 26). After an examination of these types and all the similar material in the National Museum collections from the "silex beds," I am of the opinion that a few may be molds of *Lithophaga* burrows; but with respect to those having the characteristic spiral apex, I demur. *Lithophaga* has no operculum, does not close its burrow, and possesses no other mechanism that would account for the origin of the spiral in the fossils.

There seems to be no question that the Wyoming and Florida specimens represent relics of the same type of organism, though the species may well be different, but not at present definitely separable. The Florida specimens (Fig. 1) differ from the Wyoming specimens chiefly as follows: They are composed of chalcedony and may be solid or partially solid with free water in the unfilled space, visible when the specimen is handled. They are somewhat shorter and stouter, and the apical spire in most cases is narrower and longer. They are found in sediments that were deposited in the marine or brackish water of an estuary or bay. These differences in structure, composition, and occurrence, fortunately for the argument, are not mutually exclusive and fatal, when it is remembered that the fauna of the "silex beds," besides some 300 marine and brackish-water mollusks, also includes 24 species of land and fresh-water shells.[4] Evidently land was close to the site of deposition of these beds. It seems

[2] Scudder, S. H. *The Tertiary insects of North America.* U. S. Geol. Survey Terr. Rept. **13**: 139–153, *pl. 4, figs. 5–7, 13–16, 18–21, 23.* 1890.

[3] Dall, W. H. *A monograph of the molluscan fauna of the Orthaulax pugnax zone of the Oligocene of Tampa, Fla.* U. S. Nat. Mus. Bull. **90**: 129, *pl. 24, fig. 4; pl. 26, fig. 7.* 1915.

[4] Cooke, C. Wythe, and Mossom, Stuart. *Geology of Florida.* Florida Geol. Survey Ann. Rept. **20**: 82. 1929.

therefore that any explanation that presumes to account for the ultimate origin of these objects in one case must apply, perhaps with some slight modification, to the other also.

No identification seeming acceptable at the time, these specimens were temporarily set aside and did not claim attention again until August 27 of this year (1934). On that day geological field work brought me to a locality one-half mile up Cove Creek from its mouth on the Weiser River, 9 miles east of Weiser, Idaho. There, on the

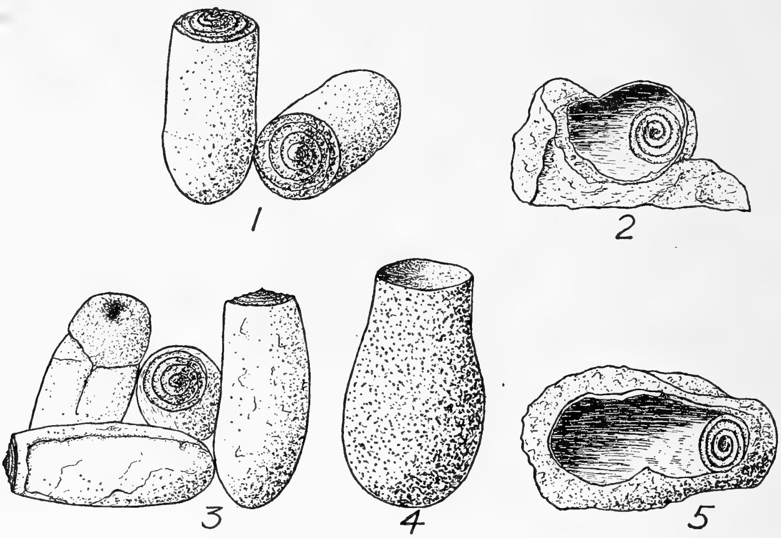


Fig. 1.—Lower Miocene fossil molds from the "silex beds" of the Tampa limestone, Tampa Bay, Fla. Fig. 2.—Apical interior of the larval chamber of *Entechnia taurea* (Say) Patton. Fig. 3.—Upper Eocene fossil molds from Mountainview, Wyo. The left upright specimen retains a portion of the chamber and seal. Fig. 4.—Sandy larval chamber of a living bee from a cliff near Weiser, Idaho. Fig. 5.—Interior of the larval chamber of *Emphor fuscojubatus* Cockerell. The spiral is the reverse of that in Fig. 2. All figures natural size.

east side of an irrigation ditch, I found an exposure of soft sandstone the face of which was riddled with small holes, a centimeter or less in diameter. When excavated, these proved to be the entrances to the burrows leading to the larval chambers of a living species of mining bee, presumably an anthophorid. The chambers were well-formed with thin walls of fine sand held together by a dark brown cement. Some were empty, some were filled with sand and other debris, but a few were sealed and apparently perfect (Fig. 4). They contained, however, only small masses of pollen and remnants of pupa cases, principally of dermestid beetles. Further search did not produce an unmolested, loaded chamber, so that the exact identity of the

builder remains unknown. The opened chambers, though disappointing in contents, nevertheless revealed some startlingly arresting characters. These were the size, shape, and smoothness of the interiors and the faint spiral mark on the inside of the seal. Could such interiors have been the molds from which nature by geological processes cast the problematic objects brought back from Wyoming by the Smithsonian expedition?

On my return to the Capital I sought the advice and assistance of entomologists working at the U. S. National Museum, in particular, R. A. Cushman, J. C. Bridwell, and Grace A. Sandhouse, who searched their collections and produced, among others, the larval chamber of an anthophorid bee, *Emphor fuscojubatus* Cockerell (perhaps a form of *Emphor bombiformis* Cresson), collected at Chesapeake Beach, Md., by Bridwell in 1920. The apical interior of this specimen (Fig. 5) and that of a chamber of *Entechnia taurea* (Say) Patton, collected by Bridwell and the writer in an abandoned clay pit near Arlington, Va., October 27, 1934, show the spiral feature of the seal very clearly. These spirals are counterparts of those on the fossils in that instead of having grooved turns they have turns whose surface is convex toward the interior of the chamber. Examination of the abundant material of *Entechnia taurea* from Arlington indicates that the spirals of the chambers containing well-developed healthy larvae are almost always faint or completely obliterated; but that those in cells which were not provisioned or that proved to be "duds" for one reason or another, are usually sharply defined.

Since the sealing of the chamber is an operation performed in the privacy and semi-darkness of an underground burrow, there is some excuse for the lack of precise recorded observations on the process. A few papers[5] get close to it, but so far I have found only one publication[6] that figures the inside of the seal and speculates upon the technique of its construction. Wesenberg-Lund, however, pictures the inside of the seal (his Fig. 4, Pl. 2) made by *Anthophora parietina* Fabricius as showing concentric circles about a small hole through which, he says, the bee thrust her tongue and coated the surface with

[5] GROSSBECK, J. A. *A contribution toward the life history of Emphor bombiformis Cresson.* N. Y. Entomol. Soc. Jour. **19**: 238–244. 1911.

NICHOLS, N. LOUISE. *Some observations on the nesting habits of the mining bee, Emphor fuscojubatus Cockerell.* Psyche **20**: 107–112. 1913.

BISCHOFF, H. *Biologie der Hymenopteren.* Biologische Studienbücher **5**: 229–230. 1927.

RAU, PHIL. *The nesting habits of Emphor bombiformis Cresson.* Brooklyn Entomol. Soc. Bull. **25**: 28–34. *figs. 1–5.* 1930.

[6] WESENBERG-LUND, C. *Traek af Linnes vaegge-bi's (Anthophora parietina Fabr.) biologi og anatomi.* Entomolgiske Medelelser (Copenhagen) **2**: 97–120, *pl. 2.* 1889–90.

a limy substance. I have not seen chambers of *A. parietina,* but those of *A. abrupta* Say, a related species, do not suggest confirmation of all Wesenberg-Lund's conclusions. The cells of this species are lined with a thin white coating, but it does not react with either hydrochloric or acetic acid, the latter being the reagent used by Wesenberg-Lund. The minute hole may or may not be present, as is also the case with *Entechnia taurea,* but the marks around it are the turns of a spiral and not of concentric circles. Bischoff, cited above, also records spirals in the genus *Tetralonia.* Lack of further adequate material prevents an authoritative statement at this time as to how widespread is the occurrence of the spiral seal among the mining bees, or whether some species make more conspicuous spirals than others.

The existence of suggestive living forms from the predecessors of which the fossils may possibly have been derived, having been pointed out, it will now be necessary, since direct testimony is absent, to marshal the circumstantial evidence in support of the probability that the fossils may be the molds of the interiors of the larval chambers of a hymenopteron. It is not my intention to tie the fossils to any particular living genus and species, but rather to suggest that the relations between the two phenomena are those of biologic affinity and not merely of striking analogy.

The size and shape of the fossils with their spiral apices conform to the interiors of the larval chambers of some anthophorid bees. In these characters the bee chambers vary considerably. Some are long, of medium width, and more or less slightly bent; others are short, stout, and straight. Some are constricted rather sharply at the apex; others are more wide-mouthed. The spirals of the seal are sometimes perfect, sometimes crude, or perhaps absent altogether. They may be high, low, or even depressed, that is, with the apex directed toward the interior of the chamber. All these features and their variations find counterparts in the fossils. In some instances the fossils have irregular deposits of clay on their surfaces that apparently represent portions of the wall and neck of the larval chambers in which they were formed.

In conjunction with the characters already mentioned, the smoothness of the fossil surfaces may be offered as additional corroborative evidence. These smooth surfaces are the kind one would expect to find on fossils derived from the polished interiors of bee chambers by the infiltration of mineral substances. This smoothness suggests that the fossils originated from bee rather than from wasp chambers, because, according to well-authenticated observations, many digger

wasps that store their larval chambers with animal prey, build rough, unfinished chambers and do not seal them with a cemented plug but merely kick sand and soil into a compact heap at the mouth of the cell and continue thus to fill up the burrow to the exit at the surface of the ground. On the other hand, the colonial mining bees that gather nectar and pollen, polish and veneer their chambers, leaving the surfaces smooth and, for a time, relatively impervious. This procedure is apparently necessary to prevent leakage from the interior and damage from the exterior during the filling of the cell and the development of the larva as it feeds upon the stored liquid or semiliquid provisions.

It may be objected, as an alternative explanation, that the spiral apex of the fossils means relationship to a snail. This suggestion, however, cannot be entertained because the spiral is the only snail characteristic present in the fossils. The shell of no gastropod mollusk of land, fresh water, or marine type fits either the form or the locality requirements of these fossils.

Can a sequence of circumstances be imagined that would explain the origin of these fossils from bee chambers without doing violence to geologic principles? A satisfactory reply to this question must obviously first account for the absence of actual insect remains in the fossils. Since limestone strata in many parts of the world are noted for their rich fossil contents, why should these calcite molds not preserve the pupal skins or other parts of the former inhabitants of the chambers? The explanation is empirical. The purer fossiliferous limestone strata rarely, if ever, preserve the softer, phosphatic portions of organisms but do preserve such hard parts as shells and bones, or their impressions, from which most or all the phosphates have been leached and been replaced by calcium carbonate. It is therefore not surprising, at least to a paleontologist, to find no insect remains in these almost pure calcite molds.[7]

The geologic method by which these molds originated is that illustrated by the formation of those geodes that are the result of cavity fillings. It was necessary that a fortunate geologic incident cause the bee chambers to be bathed for a time in waters charged with calcium carbonate or bicarbonate, so that those infiltrating solutions could fill the cavities. Since the exact source-bed from which the Wyoming fossils were weathered is not definitely known, it seems almost idle to speculate on the precise nature of the geologic incident or series of

[7] See discussion of chitin in PACKARD, A. S. *A textbook of entomology*, p. 29, 1898.

incidents that caused the influx of lime waters to the area of the bee chambers. Was it faulting, land-slipping, subsidence, climatic change, collapse of a sink, or some other event that brought the chambers within the influence of such waters and permitted the infiltration and precipitation of calcium carbonate? The habitats of living anthophorid bees are varied and it is not inconceivable or unreasonable that in the relatively long course of Tertiary history a few favorable accidents should have resulted in the production of fossils from bee chambers.

The Florida specimens from the "silex beds" present an interesting variation on this theme in that they are composed of chalcedony instead of calcite. It is my opinion that the bee chambers here concerned were originally located in a sea-cliff, stream bank, or elevated mud flat near the coast. Weathering out of the cliff and falling into the water, or with subsidence of the area, they were buried together with marine and fresh-water debris, the whole forming what is now known as the Tampa limestone. It is quite possible that calcite first filled the unbroken chambers, but that later, with elevation of the strata above sea level, it was replaced by silica, an exchange that seems even now in progress among the fossils in the upper layers of the formation.

Since entomologists agree that the history of the solitary bees and wasps extends backward at least to the Eocene, if not to the Cretaceous, there need be no objection on the score of geologic age to the idea that these fossils may represent objects associated with the life cycle of those Hymenoptera. The present geographic distribution of the anthophorid bees is amply sufficient to include occurrences in Wyoming and Florida, and by inference I judge that some species may have been as widely distributed in upper Eocene and lower Miocene time. I have not seen the photographs or specimens reported by Buxton[8] of supposed bee chambers taken from a cave in Palestine. They were, however, associated with remains of ancient man and are, therefore, apparently of late geologic age.

If the identification of these fossils as stated here is correct, the unbroken specimens with seal intact suggest, in effect, tragic incidents of the insect world of 30 million years ago. Then, as now, on account of parasitism and other causes, many bee larvae never matured to break the seals of their earthen chambers and to emerge as adults. The fossil molds are the only records of their frustrated lives.

[8] Buxton, P. A. *Ancient workings of insects, perhaps bees, from Megiddo, Palestine.* Entomol. Soc. London Proc. **7**: pt. **1**: 2–4. 1932.

For the purpose of convenient reference I have deemed it wise to name these fossils but without implying identity with any living species of bee. The name, *Celliforma spirifer*, is designed to mean "the spiral-bearing form of a cell."

PALEONTOLOGY.—*Land shells from the Upper Eocene Sespe deposits, California.*[1] G. DALLAS HANNA, California Academy of Sciences. (Communicated by JOHN B. REESIDE, JR.)

Fossil land shells have been found so seldom in the older Tertiary sedimentary rocks of California that the small collection of specimens, submitted to me by Dr. Chester Stock, seems well worthy of record. The shells were found in the course of quarrying operations for fossil vertebrates in the Sespe deposits and are preserved in a dark red and green matrix, so characteristic of the Sespe in general. All of the specimens are more or less imperfect. An association with fossil mammalian remains in the stratum in which they occurred, places their age as upper Eocene.[2] This type may be described as follows:

Helminthoglypta? stocki Hanna, n. sp.
Figures 1 to 3a

Shell large, globose, narrowly umbilicate; whorls about $6\frac{1}{2}$ to 7, sutures moderately impressed; aperture and peristome not preserved, but apparently these are not expanded; shell extremely thin and sculptured only with delicate evenly developed growth lines.

MEASUREMENTS

	Altitude	Diameter
Holotype	32 mm.	38.5 (Slightly immature)
Paratype	27.5	41 (Crushed)
Paratype	26.5	36.5 (Immature)

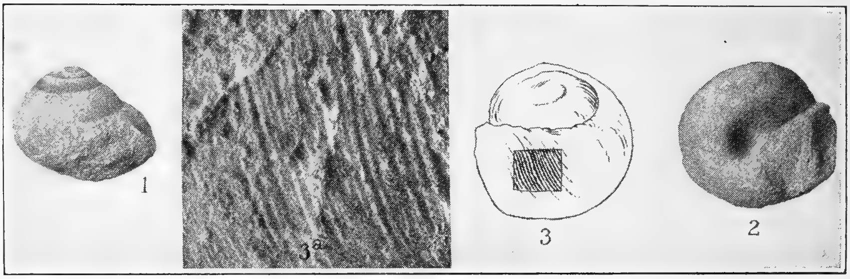
Holotype, No. 3244, and two paratypes, Nos. 3245, 3246, from the upper Eocene Sespe deposits, north of the Simi Valley, Ventura County, California. Field Locality 180 Calif. Inst. Tech. Vert. Pal. Shells in the invertebrate collections of the California Institute.

The essential characters for diagnosis of the species in *Helminthoglypta* are apparent. The moderately elevated spire and generally globose shape are features found in no other west American species. In these characters the Sespe shells resemble "*Helix*" *leidyi* Hall and Meek[3] from the Oligocene White River Group of the eastern slope of the Rocky Mountains. That species, however, is usually smaller and somewhat more globose, according

[1] Received November 8, 1934.
[2] Stock, C. Proc. Nat. Acad. Sci. **20**: 150–154; 349–354. 1934.
[3] HALL, J. and MEEK, F. B. Mem. Amer. Acad. Arts and Sci., n.s. **5**: 394, *pl. 3, fig. 12.* 1854. This species was placed in the new genus *Pseudolisinoe* by Wenz (Foss. Cat. pt. 18, no. **2**: 365. 1923), the type being *Helix veterna* Meek and Hayden.

to published figures and measurements[4] and specimens in the California Academy of Sciences.

The only living species in California comparable to this in shape is a large form belonging to the *H. tudiculata* group collected in 1933 by C. C. Church in Tulare County. In a set of nine shells collected by Mr. Church, the largest is 42 mm. in diameter and 29 mm. in altitude; the smallest is



Figs. 1–3*a*.—*Helminthoglypta?(stocki* Hanna. Fig. 1.—Holotype, no. 3244, anterior view. Fig. 2–3*a*.—Paratype, no. 3246. Fig. 2.—Basal view. Fig. 3a.—Enlargement of sculpture lines whose position is shown by rectangle in fig. 3.

36 mm. and 26 mm., respectively. Thus the shell is less globose than the Sespe fossil; also the surface of the living form is heavily malleate. Messrs. Church and A. G. Smith have the Tulare County shell under consideration for description.

The Tejon form, *H. obtusa* Anderson and Hanna[5] is much smaller (diam. 16 mm.), less depressed, and altogether a different shell. *Micrarionta dallasi* Hanna,[6] from the Eocene of the San Diego region, is likewise smaller (diam. 10.5 mm.) and less globose. No other described fossil forms appear to be sufficiently close to need comparison. Several small collections of land shells have been obtained by various parties during recent years in the southeast corner of Kern County, in a Tertiary formation which has been called "Walker." Preservation is usually rather poor and critical study has been postponed in expectation that better material might be discovered. It is possible that the present species may be there represented. The age of the formation is somewhat uncertain, but it lies below the Temblor (middle Miocene) and rests upon granite. The best specimen available was collected by William Barbat, 1,000 feet west of Pyramid Hill, Kern County, in sediments that were thought to belong to the lower Temblor. This shell has a dome-shaped spire, closed umbilicus, and is considerably larger than any of the Sespe specimens.

[4] Cockerell, T. D. A. and Henderson, Junius, Bull. Amer. Mus. Nat. Hist. **31**: 232, *pl. 22, figs. 1–3.* 1912.
[5] Anderson, F. M. and Hanna, G. D. Occ. Papers Calif. Acad. Sci. **11**: 142, *pl. 3, figs. 12, 13.* 1925.
[6] Hanna, M. A., Univ. Calif. Publ. Geol. **16**: 330, *pl. 57, figs. 8, 11.* 1927.

The problem of allocation of fossil land shells to the proper genera has been difficult for paleontologists to solve. The temptation is strong to create new group names without tangible morphological characters and solely on the basis of geologic or geographic position of the specimens. However, it seems best in this regard, when no pronounced structural differences can be found, to follow the work of such authors as Pilsbry,[7] Cockerell and Henderson and refer the species to the genus which lives in the region today.

[7] PILSBRY, H. A., Manual of Conchology, ser. 2, vol. 9, p. XLIV. 1894.

PALEONTOLOGY.—Pleurotomaria pseudostrigillata *nom. nov. and* Chonetes acanthophorus *nom. nov.*[1] GEORGE H. GIRTY, U. S. Geological Survey.

In the course of describing the Guadalupian fauna in 1908[2] I unwittingly named one of the species *Pleurotomaria strigillata,* overlooking the fact that Herrick[3] had already described a Waverly species under that name. The Guadalupian species should now be known as *Pleurotomaria pseudostrigillata.* Furthermore, Mr. Ralph H. King has considerately called my attention to the circumstance that my *Chonetes granulifer* var. *armatus*[4] is virtually a homonym of *Chonetes armatus*[5] Norwood and Pratten 1854, a name even at that time preoccupied by Bouchard.[6] I propose to substitute *Chonetes acanthophorus* for the form found in the Wewoka formation. Acknowledgment for some of these references is gratefully made to Mr. King.

[1] Published by permission of the Director of the U. S. Geological survey. Received November 8, 1934.
[2] U. S. Geol. Survey Prof. Paper **58**: *pl. 24, figs. 21, 21a.* 1908.
[3] Bull. Sc. Lab. Denison Univ. **3**: 86, *pl. 1, figs. 10, 15; pl. 2, fig. 25.* 1888.
[4] U. S. Geol. Survey Bull. **544**: 62, *pl. 7, figs. 2–4.* 1915.
[5] Acad. Nat. Sci. Philadelphia Jour. **3**: 28. 1854.
[6] See MURCHISON, DE VERNEUIL, and KEYSERLING, Geologie de la Russie, etc. **2**: 241. 1845.

BOTANY.—*The inflorescence in* Schizostachyum *Nees.*[1] F. A. McCLURE, Lingnan University. (Communicated by A. S. HITCHCOCK.)

During the course of a study of the Chinese species of *Schizostachyum* just completed,[2] it became apparent to the writer from a comparison of numerous herbarium specimens with their published descriptions, and from a study of various published descriptions of the genus, that the structure of the inflorescence is not as well understood as it should be. Reasons for this are not difficult to find. The fluid and unusual nature of the inflorescence in this genus has caused no

[1] Received July 27, 1934.
[2] To appear shortly in the Lingnan Science Journal.

end of confusion, and the terminology used in the descriptions has, almost without exception, been inconsistent and misleading, largely because of faulty interpretations of the component structures.[3]

Although Nees (1829) made allusion, in the name of the genus,[4] to one of its fundamental characters, it would seem, judging from his description, that he did not himself fully comprehend the significance of the character in terms of the morphology of the inflorescence.

The genus was briefly described by Nees on the basis of a single species collected by Blume in Java. When Ruprecht (1839) prepared his monograph two additional species were recognized. Ruprecht revealed a sense of dissatisfaction with Nees's terminology as well as an uncertainty as to the correctness of his own, and for the most part his description of the genus shows little improvement over Nees's. In fact, among other errors he made the mistake of calling the spikelets 3-flowered. Nevertheless, in a footnote (op. cit., p. 134) he arrives at a statement "Glumae in descr. Neesii sunt nostrae valvulae floram (in icone) *vel rectius bracteae spiculas vel gemmas includentes* . . ." (italics mine), which points the way to a better understanding of the inflorescence. Judging from the terminology of subsequent descriptions, however, no one seems to have given any serious attention to this hint.

Nees's original description of the genus (op. cit., p. 535) together with an emended description prepared by the writer on the basis of a study of the Chinese species, will provide a background for the discussion that follows.

SCHIZOSTACHYUM†

"Spiculae teretiusculae, glomerato-spicatae, inferne compositae interjectis inter glumas pedicellis sterilibus, uniflorae. Glumae inferiores alternatim minores, aequinerviae; superiores tres aut quatuor majores, circumvolutae, aequinerviae, quarum suprema sola fertilis. Valvulae distinctae nullae (nisi supremas squamas glumiformes valvulas existimes). Lodiculae nullae. Stamina sex, antheris linearibus erectis. Stylus simplex, longus; stigmata tria, pubescentia. Caryopsis ignota.

"Inflorescentia: spicae terminales ramorum approximatae, simplices. Spiculae in glomerulos dissitos congestae, spathis scariosis variis suffultae et interstinctae. Gramina vere bambusoidea, arborescentia, foliis petiolatis."

SCHIZOSTACHYUM BLUMII†

"Species una nobis cognita, foliis est fere pedalibus oblongo-lanceolatis acuminatis glabris, vaginis ore nudis, ligula brevissima.

"*Habitat in Java Insula: cl. Blume.*

[3] It is probable that the neglect of the prophylls as constituting a category distinct from the bracts and glumes, and the consequent failure to use them as orienting structures, are largely responsible for this faulty interpretation.

[4] From the Greek: σχιζειν = *split*, and στάχυς = *spike*.

"Adnot. Genus Beesha Kunth., Melocana [sic!] Tr. (Bambusa baccifera, Roxb. (Beesha *Rheed. H. Mal. V.* t. 60), nostro quoad spiculas proximum, differt inflorescentia, valvulis (si modo recte observata sint a scriptoribus) diversa forma distinguendis, fructu bacciformi."

The following is the writer's characterization of the genus based on a study of the Chinese species.[5]

Schizostachyum Nees emend.

Clump habit dense or open; rhizome sympodial,[6] with a tendency in some forms to run a little distance laterally before turning upward to form the culm, thus giving rise to a more open clump habit; culms erect or ascending, terete, thin-walled, usually straight, sometimes somewhat zigzag, the tips upright, drooping, or clambering; *nodes* not prominent, but usually bearing a narrow ring of pithy tissue left from the base of the deciduous sheaths; *internodes* cylindric, each smooth and shining at its base, the remaining portion with a siliceous covering which increases in thickness toward the summit of the internode, the siliceous part at first variously strewn with brittle, appressed, acicular hairs, ultimately more or less glabrescent, a zone of varying width just below the nodes usually being somewhat glaucous, more densely covered with these hairs, and more tardily glabrescent; *prophylls* (at culm nodes) ovate, obtuse, flat, shining, each containing numerous (up to 10) buds[7]; branches numerous, subequal, in fascicles, slender, the basal 2 to 6 internodes short, closely clothed with short, more or less persistent, imbricate sheaths, each sheath usually bearing in its axil a prophyll containing dormant or active buds, the branches rarely rebranching at their distal nodes; culm sheaths cylindric, convolute, coriaceous-chartaceous, usually more or less conspicuously striate or ribbed, siliceous, usually more or less covered with brittle, acicular hairs and ultimately glabrescent; *auricles* usually obsolete or nearly so; *oral setae* usually prominent; *pseudophylls* reflexed, long and narrow with involute margins and subulate tips; blades of widely varying size and shape, even on the same plant, acuminate, subulate or acicular, usually more or less rough to the touch on one or both surfaces, sometimes entirely glabrous on one surface or the other, always with several scabrous veins along the outer margin of the upper surface; the *margins* cartilaginous and more or less scabrous; the secondary veins on the under surface often with a tessellate appearance, especially in young leaves; inflorescences arising from solitary buds[7] but forming clusters, often in heads when older, sometimes more lax and open, terminal or lateral on leafy or leafless branches of primary, secondary or even higher order, sometimes (in *S. dumetorum* Munro at least) borne directly on the nodes of the main culm; the *main axis* (of the inflorescence) and the *rachis branches* of all subsequent orders, short, deter-

[5] Hitherto only 2 species have been recorded from China: *S. chinense* (a rather aberrant species, concerning the vegetative characters and habit of which little is known) and *S. dumetorum.* To these have been added *S. lima,* formerly known only from the Philippine Islands, and two newly described, apparently endemic species.

[6] Sympodial rhizomes are short and thick, with congested nodes, and are early determinate, i.e., after growing horizontally for a short distance they turn upward to form a culm. This type of rhizome gives rise to a more or less crowded or caespitose type of clump. For a fuller definition of the meaning of this term as used by the writer, see Lingnan Agr. Rev. **3**: 40–47. 1925.

[7] The examinations were made by ordinary dissection. This point should be checked by means of serial sections of the branching structure during its young stages.

minate, ultimately much branched, the branching system being indeterminate, becoming predominantly sympodial with age, the individual rachis branches each with a prophyll at its base and completely covered, in its early stages, with crowded imbricate bracts, the terminal rachis joints elongate, with expanded apices, each bearing a 1-flowered spikelet; *prophylls* (of the inflorescence) 1–8 mm. long, triangular and obtuse to linear-lanceolate and acute, the keels white-ciliate; *bracts* 1-several, gemmiferous, ovate to sublinear, obtuse and awnless to acute and more or less definitely awned, few- to many-nerved, sometimes with the central nerve forming a keel, glabrous or variously pubescent, the upper ones approaching the lemmas in size and shape; *spikelets* 1-flowered, sessile, perfect, staminate or intermediate (rudimentary perfect), the perfect ones promptly deciduous, the intermediate ones more tardily so, and the staminate ones persistent; *glumes* entirely lacking (except in *S. chinense* Rendle); *sterile lemmas* wanting (except in *S. chinense*); *lemmas* convolute, resembling upper bracts of the pseudo-spikelets, thin-chartaceous to more or less indurate, many-nerved, obscurely to definitely awned, shorter than the palea in perfect spikelets, longer than the palea and completely enveloping it in the staminate and rudimentary perfect spikelets; *paleas* convolute, often more or less spirally twisted, soft and flexible at the base, firm above, not obviously keeled but bearing dorsally a slender rachilla-joint lying in a shallow, inconspicuous sulcus, the latter becoming wider and deeper near the notched, or more or less prominently bifid, indurate apex; *rachilla* not disarticulating (except the basal joint in *S. chinense*), the terminal joint (at back of palea) pearly-white, flattened at the base, slender, bristle-like, often tipped with a minute, bud-like or leaf-like structure (rudimentary floret?), the latter being more conspicuous in staminate spikelets; *lodicules* wanting (except in *S. chinense*); *stamens* 6 (sometimes 7), included or exserted, with flat filaments, the anthers with blunt apices and unequally bifid bases; *pistils* stipitate, with the narrow, linear ovary attenuate into a slender style terminated by usually 3, sometimes 2, plumose stigmas; *fruit* (in *S. dumetorum*; unknown for the other Chinese species) fusiform, with a long, slender beak, the coriaceous pericarp separable from the grain or seed except at the back.

The inflorescences of the Schizostachyums that have been studied by the writer are borne at the distal nodes of leafy or leafless branches of primary, secondary or even higher order, or they may sometimes be borne directly upon the nodes of the main culm. The primary buds giving rise to the inflorescences are apparently solitary, but each develops into a complicated, though usually short, branching system. The main axis and the individual branches of the rachis are more or less promptly determinate, always ending in a 1-flowered spikelet, which may be perfect, staminate, or intermediate. Moreover, there is a tendency, more obvious in older inflorescences, toward typical sympodial branching (fig. 1, A and B).

While the individual branches of the rachis are thus determinate in their development, the inflorescence as a whole is entirely indeterminate, being enlarged, or rather made more dense, by the continued development of new branches from the buds in the axils of the bracts. The writer has records which indicate definitely that in several species of this genus a given in-

florescence may produce new rachis branches and new spikelets in the second year. This behavior is apparently common to all the species studied, and it is probable that the process may go on for an even longer period than has been indicated by the records. Camus (1913) p. 173, no doubt refers to this same phenomenon when he says of *S. Zollingeri* Steud. "parfois les fascicules inférieurs prolifères."

Pilger (1927) observed the presence of a similar branching system in the

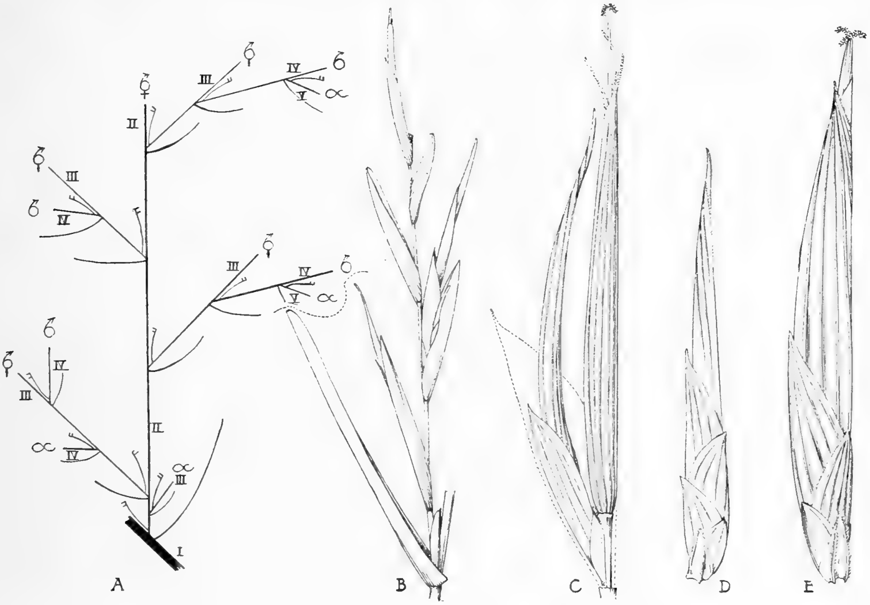


Fig. 1.—A. Diagram of an inflorescence of *Schizostachyum lima* which may be taken as typical for the genus. The Roman numerals indicate the order of the rachis branches, counting the branch from which they originated as I. ⚥ indicates fully developed perfect spikelets; ⚥ indicates rudimentary perfect spikelets; ♂ indicates staminate spikelets; ∝ indicates a bud or an incompletely developed branch. The bracts, and the sheath subtending the inflorescence, are indicated by simple curved lines, while the prophylls are shown as curved lines with two short lines inserted at right angles at their tips. B. A sketch of an inflorescence of *S. lima*. Some of the bracts, as well as the sheath subtending the inflorescence, have lost their pseudophylls. ×1. C. A portion of the tip of a rachis branch (pseudo-spikelet) of *S. lima* in an advanced stage of development. The lateral buds have produced branches which destroy its original spikelet-like appearance. The perfect spikelet (terminal) is supported by a short lateral branch (another little pseudo-spikelet) terminated by a staminate spikelet. The subtending bract is indicated by broken lines. ×3. D. A small pseudo-spikelet of *S. hainanense* terminated by a staminate spikelet. ×5. E. A pseudo-spikelet of *S. hainanense* terminated by a perfect spikelet. Note the 2-keeled prophyll at its base. Each of the four bracts bears in its axil a bud capable of developing into another pseudo-spikelet. ×5.

inflorescence of *Guadua tessmannii* Pilg., and Möbius (1898) recorded for *Bambusa vulgaris* Wendl. the development, in the second year of its flowering, of buds from a year-old rachis branch into new "spikelets." It is probable that this behavior is more common in other genera also than is generally suspected.

It is important to point out, at this juncture, that the fully developed perfect spikelets are rather promptly deciduous, while the rudimentary perfect ones fall much more tardily, the staminate ones being persistent. This behavior, operating along with the continuous development of new rachis branches, results in a growing preponderance, in specimens which have been flowering for some time, of imperfectly developed (or rudimentary) perfect spikelets, along with the staminate ones. In the course of ordinary handling, any remaining perfect spikelets may easily be lost, as well as many of the somewhat rudimentary ones. And when it is remembered that the shape and relative size of the component parts of the spikelet vary with the sexual state of the spikelet, it is easy to see how one may gain an entirely different impression from the examination of young inflorescences as compared with that to be gained from the examination of those which have undergone a long development.

It is an easy matter to ascertain the relative, if not the actual, age of the inflorescences of Schizostachyums in herbarium specimens or elsewhere. As a result of the continued development of additional branches in a system in which the main axis and all of the branches are very short, the older the inflorescence, generally speaking, the more crowded it will have become. In specimens in which flowering has continued for more than a year the contrast between the new and the old parts will be readily apparent when one looks for it. The older spikelets and structures will have a blanched appearance and be brittle, and will probably be more or less damaged, while those of the current year's growth will have a fresher, firmer appearance, and will often retain a greenish tinge. The relative number of bare rachis tips in a given inflorescence will be an index to the number of perfect spikelets that have fallen. Furthermore, it should be remembered that in fully developed perfect spikelets the palea always is exserted, however slightly, beyond the tip of the lemma. If there are no spikelets in this condition, the inflorescences are either very young (in which case there will be no naked rachis tips) or they are very old (in which case the naked rachis tips will be relatively numerous.

The branches of the rachis are covered with gemmiferous bracts.[8] Before their buds have developed, these branches have the appearance of spikelets, for which structures they have commonly been mistaken (fig. 1, D and E). The presence, however, of a prophyll[9] (often described as a 2-keeled glume) at the base of each, and of buds in the axils of the bracts (so-called gem-

[8] In the very rare cases where a bud was not found in the axil of a bract, it seemed likely that, being quite small, it was overlooked or lost.

[9] The prophyll has been largely neglected in the published descriptions of bamboos. And while it is not entirely lacking in taxonomic value, Takenouchi (1931) has perhaps over-emphasized the usefulness of its characters for distinguishing species. This structure has been of the greatest value to the writer, however, as an orienting structure leading to an understanding of the morphology of the inflorescence in *Schizostachyum*, where the small size and the extremely crowded condition of the floral structures make ordinary dissection particularly difficult. It is perhaps in connection with this aspect of bamboo study that its usefulness should be more strongly emphasized.

miferous glumes), reveals their true nature immediately.[10] As soon, however, as the lateral buds of a given rachis branch have developed to any extent, it loses its spikelet-like appearance, and the terminal spikelet itself becomes more evident. In those species which have the terminal rachis joints most elongate, the true spikelet is likewise more easily discernible. In such species the terminal perfect spikelets are typically seen to be supported on one side by a short rachis branch terminated by a staminate spikelet (fig. 1, C). Camus (1913), p. 177, would seem to be referring to this condition when he says of *S. latifolium* Gamble, "Epillets . . . groupés par 2 . . ."

SUMMARY

1. The structure of the inflorescence in the genus *Schizostachyum* has been misinterpreted since its first description, and the terminology used has been inconsistent and misleading.

2. It is suggested that the neglect of the prophylls as constituting a category distinct from the bracts and glumes, and the consequent failure to use them as orienting structures are largely responsible for this faulty interpretation.

3. As a background for the discussion Nees's original description of the genus and the type species is given, along with the writer's own recently prepared emended description of the genus based on a study of the Chinese species.

4. The following sources of confusion in the interpretation of the inflorescence of *Schizostachyum* are pointed out:

a. The indeterminate nature of the inflorescence as a whole, which grows out of the successive development of additional rachis buds.

b. The unusual, spikelet-like form taken by the determinate rachis branches (pseudo-spikelets).

c. The fact that the spikelets terminating these branches of the rachis may represent any sexual state from purely staminate, through rudimentary perfect, to fully developed perfect, with corresponding discrepancies in the shape and relative size of the different component structures.

d. The fact that there may exist, in a given inflorescence at a given moment, spikelets (as well as the rachis branches which they terminate) in various stages of development.

e. The prompt deciduousness of the fully developed perfect spikelets, which leaves, in the older inflorescences, an impression that certain more tardily deciduous forms of the spikelet are representative, because most numerous.

[10] As an aid in making clear the distinction between these structures and the real spikelets, the term *pseudo-spikelet* has been used, in the descriptions recently prepared by the writer, to indicate these bract-covered ultimate branches of the rachis. The proper significance of this term, as well as the modern sense of the terms *bract* and *glume*, (Chase, 1922 and Piper, 1906) should be kept in mind in comparing these with the older descriptions. The structures referred to in the existing descriptions as "glumes" or "gemmiferous glumes" are really, for the most part, *bracts*. Glumes, in the modern sense, are lacking in all the Chinese species of the genus except *S. chinense*. This species is also aberrant among the Chinese species in the possession of lodicules, a sterile lemma, and a disarticulating rachilla.

ACKNOWLEDGMENTS

The present paper is the beginning of the fruition of field work on the Chinese bamboos begun in 1921, and is based on herbarium material and notes brought together chiefly by the writer and the staff of the Lingnan University Herbarium. Full acknowledgment is made elsewhere of special financial assistance for this work received from various outside sources, but special mention is due the Rockefeller Foundation for its most recent grant, which has made possible the purchase of hitherto unavailable literature and equipment essential to the continued pursuit of this work.

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TAKENOUCHI, Y. *Systematisch-vergleichende Morphologie und Anatomie der Vegetationsorgane der japonischen Bambus-Arten.* Mem. Fac. Sci. Agr. Taihoku Imp. Univ. **3**: 37–53, *fig. 22–29, pl. 3.* 1931.

[11] This paper was first issued in 1839 as a separate with pagination 1–74. When it appeared in the regular series in 1840 the pagination was changed to 91–164. Thus, in the latter place our reference would be pp. 133–7.

BOTANY.—Pleuroderris, *a new genus of Middle American ferns.*[1] WILLIAM R. MAXON, National Museum.

The genus *Hypoderris* R. Br., first mentioned with a few words of description in 1830,[2] was fully described and figured somewhat later by Hooker[3] on the basis of a single species, *H. Brownii* J. Sm., from Trinidad, which has since been found rather commonly in Porto Rico, also in Hispaniola and Grenada, and very recently has been reported from Venezuela.[4] This plant has the general habit and venation of *Tectaria trifoliata*, and in fact closely resembles young individuals of that species. It has been classified nevertheless as belonging not to the Dryopterideae, but to the tribe Woodsieae, because of its curious indusia. These are inferior in attachment and at first subglobose, enclosing the sporangia, but soon become circular, pateriform and flattish, and shallowly lobed on all sides, with fimbriate-ciliate margins.

In addition, five other species have been described under *Hypoderris*, for the most part independently or upon scant material. The latest of these, *H. Stuebelii* Hieron.,[5] founded upon a sterile plant from Ecuador, has since been referred to *Leptochilus*.[6] Of the remaining four, two were described from Nicaragua by Fournier, one from Nicaragua by Prentice, and one from Guatemala by Christ. All five, though exhibiting great variation in leaf form according to age and habitat, as well as in soriation, actually represent but a single species, which departs widely in sorus characters from the genotype, *H. Brownii*, and may be regarded tentatively as constituting a new genus. However, this plant had previously been described from the Darien region as *Lindsaea* (*Dictyoxiphium*) *Michleriana* Eaton, which is thus the name-bringing synonym. Because of the laterally attached indusia its repeated description by several authors under *Hypoderris*, in which, as already remarked, the indusium is truly inferior in attachment, is hard to understand, whatever its true relationship may be. Oddly enough the presence of any indusium whatever was overlooked by Baker in describing in the Synopsis Filicum this species once more as new, from Nicaragua, under the name *Polypodium* (*Dictyopteris*) *Tatei*. In the same volume also (p. 113) Baker re-

[1] Published by permission of the Secretary of the Smithsonian Institution. Received October 30, 1934.
[2] R. Br. (note) in Wall. Icon. Pl. Asiat. Rar. **1**: 16. 1830.
[3] Gen. Fil. *pl. 1.* 1838.
[4] Revista Sudamer. Bot. **1**: 82. 1934.
[5] Hedwigia **46**: 323. 1907.
[6] *Leptochilus Stuebelii* (Hieron.) Maxon, Proc. Biol. Soc. Washington **46**: 142. 1933.

described *Lindsaea Michleriana* under the genus *Lindsaea*, transferring it however to the subgenus *Diellia*, obviously on the basis of specimens at hand. So we have the rare anomaly of his recognizing one and the same species under three wholly different names, contemporaneously, viz., *Lindsaea Michleriana*, *Hypoderris Seemanni*, and *Polypodium Tatei!*

Type material of all six of the "species" just mentioned has been studied by the writer in connection with a very ample recent series of specimens from the lowland region of Juan Diaz, about 10 miles east of Panama City. From this whole range of specimens the new genus, consisting of a single highly variable species, is described herewith. Its possible origin as a bigeneric hybrid is discussed below. The name adopted relates to the lateral attachment and position of the indusia.

Pleuroderris Maxon, gen. nov.

Rhizoma suberectum, paleis castaneis praeditum. Folia multa, stipitibus sulcato-angulatis rufo-castaneis inarticulatis; laminae variabiles anguste deltoideo-oblongae, attenuatae, saepe asymmetricae, basi pinnatisectae vel pinnatae, alibi grosse lobatae; segmenta majora pauca deltoideo-oblonga vel lanceolata, infima semiadnata vel sessilia plerumque repando-crenata vel sinuata, media semiadnata vel adnata, repanda vel sinuata vel subintegra, superiora gradatim minora late conjuncta, laminae apice lato elongato sinuato. Costae subtus elevatae; nervi catadromi distantes obliqui subflexuosi; venatio *Tectariae*, areolis inaequalibus saepe appendiculatis. Sori submarginales vel inter nervos irregulariter et sparse dispositi, dorsales vel compitales, magni, lunati vel vermiformes vel varie curvati, receptaculis plerumque elongatis; indusia lateralia, integra vel interdum ut videtur divisa, obscure ciliolata; sporangia numerosissima longe pedicellata plerumque abortiva vel deformia, annulo incrassato ca. 13-articulato, sporis perpaucis alte et tenuiter echinato-alatis; paraphyses nullae.

A terrestrial fern of wet forest ravines, the rhizome stout, suberect, paleaceous. Fronds many, of medium size, ascending, the stipes firm, sulcate-angulate, rufo-castaneous, not jointed to the rhizome; blades variable, narrowly deltoid-oblong, attenuate, often asymmetrical, coarsely lobed, pinnatifid, or (at base) pinnatisect or fully pinnate; pinnae and larger lobes usually few, simple, deltoid-oblong to lance-attenuate, the basal ones of large blades semiadnate or rarely sessile, mostly sinuate to coarsely repand-crenate, those above adnate to semiadnate, long-decurrent, repand to subentire, the upper ones gradually reduced, broadly joined below the broad, greatly elongate, sinuate apex. Costae strongly elevated beneath; veins catadromous, distant, oblique, elevated, subflexuous, nearly reaching the margin; intermediate veinlets freely anastomosing, the costal areoles elongate, nearly or quite connecting the veins at base, the others broadly polygonal, variable, often subdivided, the ultimate areoles with or without simple or forked included veinlets. Sori irregularly disposed in a submarginal zone or sometimes borne in 1 or 2 incomplete sparse rows between the veins, dorsal or compital, mostly large, lunate to irregularly linear or variously curved, the receptacle dark, usually elongate; indusia lateral, entire or (if

greatly elongate) sometimes appearing deeply few-lobed, dark, lustrous, early thrust back and nearly concealed by the sporangia, obscurely ciliolate; sporangia very numerous, long-stalked, mostly abortive or somewhat deformed, the annulus about 13-celled; spores very few, delicately echinate-alate; paraphyses wanting.

TYPE SPECIES: *Lindsaea Michleriana* Eaton, from Colombia, the synonymy being as follows:

Pleuroderris Michleriana (Eaton) Maxon

Lindseya (*Dictyoxiphium*) *Michleriana* Eaton, Mem. Amer. Acad. n. s. **8**: 213. 1860.

Dictyoxiphium Michlerianum Moore, Ind. Fil. 319. 1861.

Hypoderris Seemanni Prentice, Journ. Bot. Brit. & For. **7**: 240. 1869.

Hypoderris marginalis Fourn. Bull. Soc. Bot. France **9**: 260. 1872.

Hypoderris adnata Fourn. Bull. Soc. Bot. France **9**: 260. 1872.

Polypodium (*Dictyopteris*) *Tatei* Baker in Hook. & Baker, Syn. Fil. ed. 2, 506. 1874.

Hypoderris heteroneuroides Christ, Bull. Herb. Boiss. II. **6**: 292. 1906.

TYPE LOCALITY: "Ad terram prope cataractum Truando Novae Granadae, *Schott* n. 8."

DISTRIBUTION: Northwestern Colombia to Guatemala, at low elevations.

ILLUSTRATION: Shimek in Bull. Lab. Nat. Hist. Univ. Iowa **4**: *pl. 18, f. 1–3.* 1897; Hook. Icon. Pl. **17**: *pl. 1670.* 1886.

Of the following specimens examined all are in the U. S. National Herbarium (N), unless otherwise indicated:

COLOMBIA: Truando Falls, Intendencia de Chocó, Feb. 1858, *Schott* 8 (herb. D. C. Eaton; dupl. at N. Y. Bot. Gard.).

PANAMA: Muddy border of small stream near Tapia River, one-half mile south of Pacora road, alt. 30 meters, Nov. 29, 1917, *Killip* 2706. Deep woods along Pacora River, Dec. 23, 1917, *Killip* 2734. Deep woods along Tapia River, Dec. 23, 1917, *Killip* 2746. Deep ravine north of Orange River, along muddy banks of small stream, Jan. 13, 1918, *Killip* 2787. Ravines of upper Juan Diaz River region, Mar. 10, 1918, *Killip* 2855. Forest along Juan Diaz River, about 4 miles above Juan Diaz, Jan. 13, 1918, *Mrs. L. R. Cornman* 648. Wet forest along Tapia River, common, Dec. 1923–Jan. 1924, *Standley* 26171, 28211. Edge of waterholes and along stream banks, in stiff clay soil often subject to inundation, near Tapia River, June 1–3, 1923, *Maxon & Harvey* 6666, 6692, 6724.

COSTA RICA: Llanuras de San Carlos, alt. 200 meters, in shade, Apr.–May, 1910, *A. & C. Brade* 487 (Berlin, N. Y. Bot. Garden; photo. and fragm., N).

NICARAGUA: Chontales, *Seemann* 206 (Br. Mus.; type of *Hypoderris Seemanni;* photo. and fragm., N). Chontales, in forest, *Lévy* 501 (type of *H. adnata*, at Paris, not seen; photo. and fragm., N). Chontales, *Lévy* 501 bis (type of *H. marginalis*, at Paris, not seen; photo. and fragm., N). Chontales, *Tate* 41/235 (type of *Polypodium Tatei*, at Kew, not seen; dupl. type at Br. Mus.; photo. and fragm. of latter, N). Near Castillo, "found sparingly on the banks of a creek in deep woods," Jan.–Feb., 1893, *Shimek* s. n. Region of Braggman's Bluff, 1928, *Engelsing* 269.

GUATEMALA: Cubilquitz, Alta Verapaz, alt. 350 meters, *von Tuerckheim* (J. D. Smith, no. 8821; type of *H. heteroneuroides;* 3 sheets, N).

Despite this wide array of material, *Pleuroderris Michleriana* is rare in

Fig. 1.—*Pleuroderris Michleriana* (Eaton) Maxon. The type specimen; about two-fifths natural size.

most herbaria, a single exception being the extensive series in the National Herbarium from the Juan Diaz region, Panama. Many of the Panama numbers are represented by two or more sheets, which show not only "abnormal" variations in leaf form but numerous intermediate stages between the young and adult conditions as well. Eaton's type specimen (fig. 1) consists of two fronds that are somewhat immature in leaf form. The well-developed, mature but not extreme form is shown in an incomplete frond of *Killip* 2787 (fig. 2). Mrs. Cornman's no. 648, from Panama, happens to be an exact match for the type material of *H. Seemanni* and *Polypodium Tatei*, from Nicaragua.

As to relationship, *Pleuroderris* is most like some species of *Tectaria*, but with sori distinctly anomalous in their widely varying structure. The venation is obviously that of *Tectaria*, and the general aspect of the plant hardly less so. The sori arise mostly at the angular intersection of the veinlets which enclose the areoles, as in certain species of *Tectaria*, but they are unique in that the sporangia usually extend in a continuous dorsal line some distance along two or more of the boundary veinlets of an areole and commonly those of an adjacent areole. The sori are thus, as a rule, elongate. Sometimes they are merely lunate or irregularly curved-linear; again they may be T-shaped or Y-shaped, according to the vein-pattern; occasionally they are hippocrepiform or nearly circular in outline. In the last case it will usually be found, on dissection, that the heavy sporangial line runs nearly around the areole and that the laterally attached indusium follows it throughout, being linear in extent though not "linear" in form. Sometimes, also, two or three sori, although of independent origin, arise closely from the same or adjacent areoles and run together at maturity to form a composite "sorus," in which case the indusium may appear coarsely few-lobed. Rarely (e.g., *Maxon & Harvey* 6692) the sorus is essentially that of *Tectaria*, with roundish-reniform indusium, the sporangia arising from a short receptacle. Besides the types just described, occasionally a sorus is borne also at the expanded tip of an included veinlet.

Details of venation and soriation are shown rather imperfectly in the illustrations by Shimek, but this author, in his interesting paper on the ferns of Nicaragua,[7] is apparently the only one to have questioned the reference of the present plant to *Hypoderris*. Although his material was inadequate he contrasted it with the type species, *H. Brownii*, directing special attention to the "transverse" indusium, which is vastly different from the inferior cuplike structure in *H. Brownii*, and concluded that the Nicaraguan plant probably represented a new genus, which however he mistakenly thought should be placed near *Cystopteris*.

The curious position and orientation of the sori in *Pleuroderris* call for comment also. Eaton describes the sori as intramarginal, interrupted, and oblong or linear, and the indusia as slender, interrupted, and "non marginem

[7] Bull. Lab. Nat. Hist. Iowa **4**: 115–224. *pl. 1–20.* 1897.

Fig. 2.—*Pleuroderris Michleriana* (Eaton) Maxon. A well-developed Panama specimen, *Killip* 2787; about two-fifths natural size.

frondis tegens." Partly because of the submarginal position of the sori in his sparingly fertile specimens he placed the species in *Lindsaea,* subgenus *Dictyoxiphium,* owing to a supposed resemblance of the sori to those of *Dictyoxiphium panamense* Hook., a newly described genotype which Mettenius,[8] knowing the plant only from description and figure, had reduced to *Lindsaea.* However, *Dictyoxiphium* has long since come to be recognized as a valid "monotypic" genus, differing widely in essential morphology from *Lindsaea.* It is a plant having large, simple, sword-shaped fronds similar in venation to *Tectaria.* In spite of similarity in habit and reticulate venation, *Dictyoxiphium panamense* differs markedly from *Pleuroderris* in soriation; the sporangia are borne in an unbroken submarginal line for nearly the entire length of the frond, the sorus being provided with a continuous, delicate, *extrorse* indusium. No such general condition exists in *Pleuroderris.* Here, it is true, the sori are largely borne in a marginal zone, but of those that are actually submarginal a bare majority face outward, some inward, and others in all directions; also they are of all shapes and sizes, and they never form even a subcontinuous series. Moreover, in some fronds the sori are borne far from the margins in a sparse double row between the nerves nearly down to the midrib, as in *Tectaria;* as a rule also the farther they are from the margin the more closely they resemble the sori of that genus. Before the sorus characters were accurately made out, in fact, several early specimens of Mr. Killip's excellent Panama series were referred to *Tectaria.* Further evidence of relationship is afforded by **Tectaria rivalis,**[9] of the Colombia-Panama region, in which the sori are occasionally oblong and provided with a reduced somewhat chitinous indusium strongly suggestive of the kind predominating in *Pleuroderris.*

But if affinity with *Tectaria* may be regarded as established, it appears no less that *Pleuroderris* departs from that genus definitely in the direction of *Dictyoxiphium,* especially in its elongate and occasionally fused sori which tend to occupy a submarginal position. May it not be a hybrid between *Dictyoxiphium panamense* and *Tectaria martinicensis,* even though these belong respectively to the tribes Davallieae and Dryopterideae? Both species were collected in the Juan Diaz region, in very close association with *Pleuroderris,* and both are companion plants of that throughout its range. Additional support for hybridity is found in the highly variable and pronounced asymmetrical shape of many of the blades in *Pleuroderris* and in the sporangia, most of which are somewhat distorted or only partially developed and apparently lack a normal sporogenous content. Coupled with the extreme diversity in shape, position, and size of sori, the last feature is of special importance. Because of the numerous young plants observed in the Juan Diaz region it may be assumed that *Pleuroderris* is there fertile, sparingly so at least, notwithstanding that after repeated examinations only

[8] Fil. Hort. Lips. 105. 1856.
[9] *Aspidium rivale* Mett.; Kuhn, Linnaea **36**: 120. 1869.

a few mature spores have been found. Though not wholly convincing, the points mentioned, particularly the intermediate character of variable soriation, offer a good deal of ground in support of hybridity.

However, *Tectaria* itself, in the modern sense, embraces plants with widely different sori and is seriously in need of revision as to American material. And in this connection the phylogenetic relationship of several genera should be considered. In particular, *Hypoderris Brownii*, though placed by most authors in the tribe Woodsieae on account of its basal indusia, was regarded by John Smith as allied to the group we now call *Tectaria*. Thus Bower's conclusions,[10] upon morphological grounds, as to the modified characters of *Hypoderris* and certain other genera of the Woodsieae in the direction of the tribe Dryopterideae are of unusual interest.

Similarly *Amphiblestra*, consisting of a single rare Venezuelan species, *A. latifolia* (Humb. & Bonpl.) Presl, although classified by nearly all fern writers as belonging to the tribe Pterideae, was associated by John Smith[11] "with *Dryomenes*, *Dictyopteris*, and *Aspidium*, especially such as *A. macrophyllum*," i.e., *Tectaria*. Kunze[12] figured and redescribed it under *Pteris*, dryly remarking that although in venation it treads upon *Phymatodes*, *Bathmium*, *Dictyoxiphium*, and other genera he was well satisfied to place it in *Pteris*. The habit, simply pinnate blades, and areolate venation are those of a *Tectaria* with very freely appendiculate areoles, but the marginal sori normally are fused to form a continuous longitudinal coenosorus which lacks a true indusium, the slightly recurved but unmodified margin scarcely functioning as such. Nevertheless, Fournier,[13] working with imperfect Nicaraguan material, redescribed the unique *Dictyoxiphium panamense* as a new species of *Amphiblestra*, so strong is the similarity in venation. Bower discusses *Amphiblestra* in connection with progressive anastomosis in *Pteris*, but leaves its systematic position in abeyance. It may indeed be a *Pteris* ally, but equally it may belong near *Tectaria*, in the Dryopterideae. It should be borne in mind that if the existence of similar indusial structures is not necessarily an indication of close relationship among the ferns, such indusia having very probably developed independently and often relatively late in various phyletic lines, so also their absence or even the development of somewhat diverse types of indusia may not always be regarded as weighing heavily against the common evolutionary origin of plants otherwise similar in structure and in habit. *Amphiblestra* is no more puzzling than *Dictyoxiphium*. These and several other groups which in venation and habit resemble *Tectaria* deserve close morphological study. *Pleuroderris* may not be a bigeneric hybrid, as suspected, yet the remarkable intermediates between *Tectaria* and *Hemigramma* which Copeland[14] discusses and illustrates

[10] The Ferns **3**: 99–119. 1928.
[11] Hist. Ferns 194. 1875.
[12] Farrnkr. **2**: 43–46. *pl. 118.* 1849.
[13] Bot. Zeit. **31**: 8. 1873, as *Amphiblestra simplex*, sp. nov.
[14] Philippine Journ. Sci. Bot. **3**: 31. *pl. 1–4.* 1908.

come to mind as a somewhat similar case. In any event it seems decidedly worth while to place on record such facts as are known about the curious plant here called *Pleuroderris* and to give it temporary status as a genus intermediate between *Tectaria* and *Dictyoxiphium*.

ZOOLOGY.—*The histology of nemic esophagi.* III. *The esophagus of* Oesophagostomum dentatum (*Rudolphi*).[1] B. G. CHITWOOD, Bureau of Animal Industry and M. B. CHITWOOD.

This paper is the third of a series dealing with the structure of nemic esophagi. In this paper the same nomenclature is used as in the previous ones (Chitwood and Chitwood, 1934 and 1934). Some notes on the esophagus of *Oesophagostomum dentatum* have been given previously by one of the writers (B. G. Chitwood, 1931), but the detailed structure of this organ was not given.

GROSS MORPHOLOGY

The gross morphology of the esophagus of the adult of *Oesophagostomum dentatum* has been given previously by Goodey (1924). The esophagus of this form is in general clavate, terminating posteriorly in an elongate swelling. Regions such as corpus and isthmus are not grossly discernible, but the regions homologous to the corpus and isthmus may be determined on the basis of nuclear distribution. In the specimens studied by the present writers the esophagus was from 360 to 400μ long, 150 to 190μ of this length comprising the corpus, 50 to 90μ the isthmus, 80 to 90μ the anterior part of the bulbar region, and 40 to 60μ the posterior part of the bulbar region. The internal covering of the esophagus is very definitely modified in the various regions. Throughout the length of the esophagus the walls of the lumen forming the radii converge distally forming an acute angle instead of a cylindrical tube as in oxyurids and rhabditids. At the extreme anterior end the lumen is subtriangular and the walls simple; 10 to 15μ posterior to this the lumen becomes much more clearly triradiate, and near the tips of the radii 6 series of thickenings are present, these being attachment points of the radial muscles. These attachment points are continued posteriad to the beginning of the posterior part of the bulbar region. In the anterior region of the corpus, minute spines project internally from the wall of the esophagus. The dorsal esophageal gland opens at the anterior end of the corpus, but the position of the orifices of the subventral glands has not been determined with certainty by the writers. Goodey (1924) stated that their orifices were situated just anterior to the beginning of the bulbar region.

The esophagus of this species, like the esophagi of other members of the Strongyloidea, undergoes many changes during development. In the first-stage larva it consists of a corpus, isthmus, and valvulate bulb identical in

[1] Received October 18, 1934.

appearance with that of adult rhabditids, while later in the development the valves degenerate and the esophagus becomes much more elongated so that at the third stage, though the regions are still apparent, the general form differs entirely from that of the first larval stage (See Goodey, 1924).

NUCLEAR DISTRIBUTION

The corpus contains 47 nuclei which fall into two general groups corresponding to the precorpus and postcorpus of other forms. However, there appears to have been some shifting of the relative positions of a few nuclei, making it difficult to set a sharp line of demarcation between the two groups. For practical purposes the first group of marginal nuclei are arbitrarily considered as indicating the beginning of the postcorpus.

Precorpus. The precorpus contains 24 nuclei as follows: 17 nerve cell nuclei (n_{1-17}), 6 radial nuclei (r_{1-6}), and 1 asymmetric nucleus of questionable significance (x_1). The latter (x_1) lies on the left side of the dorsal sector and 5 to 10μ from the anterior end of the precorpus. The radial muscle nuclei (r_{1-6}) lie near the middle of the precorpus, about 20 to 40μ from its anterior end. These nuclei are arranged as a group of 6, one being on each side of each sector.

The nerve cell nuclei ($n_{1 \text{ and } 2}$) lie near the middle of the dorsal sector, 1 on each side of the duct of the dorsal esophageal gland, 20 to 30μ from the anterior end of the precorpus. Following these nuclei there is a series of 4 nerve cell nuclei[2] ($n_{13-15 \text{ and } 18}$) in the middle of the dorsal sector and external to the duct of the esophageal gland. Of these n_{18} is usually situated at, or posterior to, the level of the marginal nuclei (m_{1-3}), and is therefore grouped as part of the postcorpus. The nerve cell nuclei $n_{3,4,5,10,11,16}$ in the left subventral sector and $n_{6,7,8,9,12,17}$ in the right subventral sector form 2 irregular chains extending throughout the length of the precorpus (Fig. 1), these nuclei being situated near the middle of the subventral sectors. Quite often the last two (n_{16-17}) are posterior to the marginal nuclei (m_{1-3}).

Postcorpus. The postcorpus contains 23 nuclei as follows: 6 radial nuclei (r_{7-12}), 3 marginal nuclei (m_{1-3}), and 14 nerve cell nuclei (n_{18-31}). Of these the marginal nuclei are considered as indicating the anterior end of the postcorpus, 1 being situated to the side of each radius of the esophagus, 2 of these ($m_{1,3}$) usually being dorsal to the subdorsal radii, and the other (m_2) usually being on the right side of the ventral radius.

The first dorsal nerve cell, n_{18}, is usually at about the same level as that of the marginal nuclei. The second and third dorsal nerve cells (n_{23-24}) are situated about 50 to 60μ from the anterior end of the postcorpus, while the last dorsal nerve cell (n_{29}) is situated 10 to 30μ posterior to these. The sub-

[2] Since the nerve cells in the precorpus follow one another so closely, there is considerable chance of error, either by considering the same cell as two cells or considering 2 cells as one and the same. We believe that any error will not involve more than 1 cell for each sector.

ventral nerve cells ($n_{19,21,\text{ and }20,22}$) are situated 10 to 20$\mu$ posterior to the marginals, while the following subventral nerve cells ($n_{25,27\text{ and }26,28}$) are situated 10 to 30$\mu$ posterior to the former (Fig. 1). The last subventral nerve cells of the postcorpus ($n_{30,31}$) are situated at the posterior end of the postcorpus, 10 to 30μ posterior to the last dorsal nerve cell (n_{29}).

The second group of radial nuclei (r_{7-12}) is arranged like the first group (r_{1-6}) and is situated 30 to 40μ from the anterior end of the postcorpus.

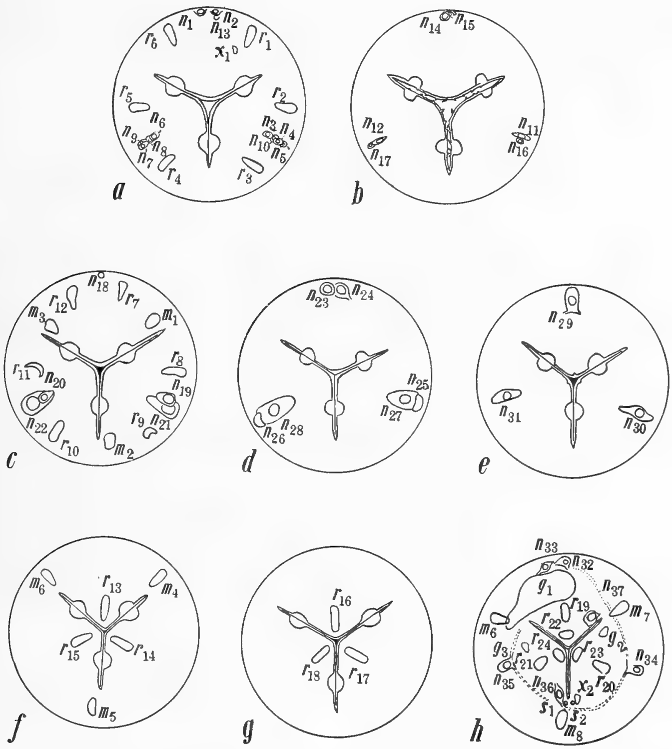

Fig. 1.—Diagrammatic representation of groups of nuclei of the esophagus. (*a–b*) Precorpus; (*c–e*) postcorpus; (*f–g*) prevalvar region; (*h*) valvar and postvalvar region. *s*, *x*, *r*, *m*, and *n* indicate the various types of nuclei.

Isthmian region. This region contains no nuclei.

Prevalvar region. The prevalvar region contains 9 nuclei as follows: 3 marginal nuclei (m_{4-6}), and 6 radial nuclei (r_{13-18}). Of these nuclei the marginals are most anterior, 1 situated near each of the esophageal radii; usually the subdorsal nuclei ($m_{4\text{ and }6}$) are located on the dorsal side of the subdorsal radii, while the ventral nucleus (m_5) is at the left side of the ventral radius.

The 6 radial nuclei are arranged in 2 groups of 3 each, 1 near the apex of each sector; the first group (r_{13-15}) is situated at approximately the same

level as the marginals, while the second group (r_{16-18}) is situated 30 to 50μ posterior to the first.

Valvar and postvalvar regions. The posterior part of the bulbar region contains 21 nuclei as follows: 3 gland cell nuclei (g_{1-3}), 6 radial nuclei (r_{19-24}), 3 marginal nuclei (m_{7-9}), 6 nerve cell nuclei (n_{32-37}), 2 nuclei possibly of nerve cells (s_{1-2}), and an additional nucleus (x_2) observed in some series.

The radial nuclei are arranged in 2 groups of 3 nuclei each ($r_{19-21 \text{ and } 22-24}$), one group being anterior to the other. The marginal nuclei (m_{7-9}) are situated near the level of the last radial group or posterior to its level, 1 nucleus situated at one side of each esophageal radius; the right subdorsal marginal nucleus is usually situated on the dorsal side, the left subdorsal on the ventral side, and the ventral on the right side of the corresponding esophageal radii. The nerve cell nuclei n_{32-33} are situated on each side of the dorsal sector near the nucleus of the dorsal gland (g_1); n_{34-35} are situated in the middle of the subventral sectors, and (n_{36}) near the ventral side of the right subventral sector. These 5 nuclei (n_{32-36}) are all situated near the same level (Fig. 1). The other nerve cell nucleus (n_{37}) is situated at about the level of the marginal nuclei at the left side of the dorsal sector. The questionable nerve cell nuclei (s_{1-2}) are symmetrically placed, 1 on each side of the ventral esophageal radius very close to the posterior end of the esophagus. Anterior to s_2 the nucleus x_2 was observed in some specimens.

Esophago-intestinal valve. It is difficult to be sure whether there are 5 or 6 nuclei present in the esophago-intestinal valve. This structure consists of an internal lobed part usually containing 3 nuclei and an external part containing 2 nuclei. Sometimes there appears to be an additional nucleus in the lobed part.

CHARACTER OF NUCLEI

The radial muscle nuclei have a moderately basophilic nucleoplasm which is nearly uniform and very finely granular. The nucleolus is often bilobed (Fig. 2) or sometimes fragmentary (Fig. 2). In the first group of radial nuclei (r_{1-6}) each nucleus is about 5.8 to 7.5μ long and usually compressed laterally; those of the second group (r_{7-12}) about 8μ long and similarly compressed; those of the third and fourth groups ($r_{13-15,16-18}$) about 9.3μ long and usually more rounded than those of the first and second group; those of the fifth group (r_{19-21}) are about 3.3μ long by 5.2μ wide; and those of the sixth group (r_{22-24}) are about 4.2μ long by 2μ wide, very much flattened in a plane parallel with the axis of the esophagus (Fig. 2). Because of their shape the nuclei of the sixth group were previously mistaken for commissural nerve cells by one of us (B. G. Chitwood, 1931). The muscular tissue associated with the nuclei of the sixth group at the level of these nuclei appears as a narrow band.

The marginal nuclei are all rather similar to the radials, each containing a single nucleolus which may be lobed (Fig. 2); the nucleoplasm is usually

less basophilic and less homogeneous than that of the radial nuclei. These nuclei are generally somewhat subtriangular, the narrowest part projecting toward the esophageal lumen. In cross section the nuclei of the first group (m_{1-3}) are approximately 8.3μ long by 4.2μ wide, those of the second group (m_{4-6}) 6.2μ long by 4μ wide, and those of the third group (m_{7-9}) 6.2μ long by 2.5μ wide.

The nucleus of the dorsal esophageal gland (g_1) is extremely large, 19μ long by 14.5μ in maximum width. Anteriorly it appears as a wide sub-

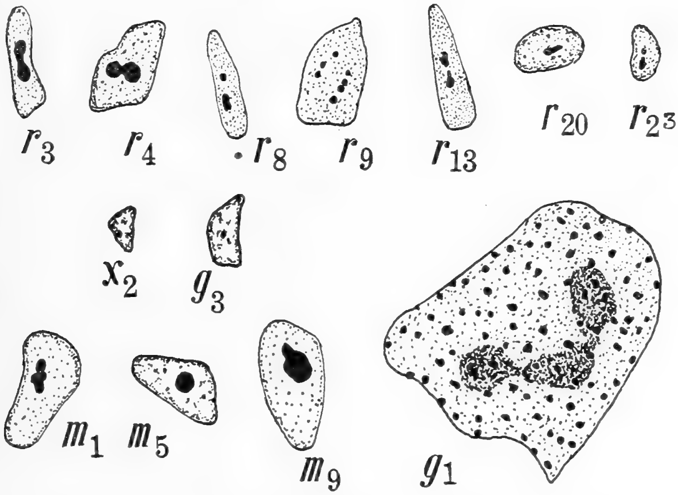

Fig. 2.—Nuclei of the esophagus. Labelled as in fig. 1.

rectangular body in the middle of the dorsal sector; it bends to the right and a narrow lobe projects over the right subdorsal margin of the esophageal lumen. It contains 1 lobed nucleolus or several fragmentary nucleoli. The nucleoplasm is delicate, homogeneous and basophilic, and shows a rather uniform scattering of coarse basophilic granules (Fig. 2). The writers are not absolutely sure that the subventral nuclei (g_{2-3}) actually belong to the subventral glands, but these nuclei appear to be situated in glandular plasma; these nuclei are 5μ long by 2.3μ wide and are similar in character to the marginal nuclei (Fig. 2).

The nerve cells, as in other nematodes, differ markedly in size and shape. Those in the precorpus, as well as the first dorsal nerve cell of the postcorpus, are small; the nuclei (Fig. 3) are stained deeply and are about 1.65 to 2.7μ long by 0.9 to 1.65μ wide. Most of the cells are apparently bipolar, very thin, and spindle-shaped, but the first 2 dorsal nerve cells (n_{1-2}) are subtriangular and may possibly be tripolar. The nerve cells of the postcorpus are all relatively large, and the nuclei stain less deeply than those of the precorpus; each nucleus contains a very small nucleolus and the surrounding

nucleoplasm contains irregular scattered chromatic granules. The nuclei are 1.89 to 4.79μ long by 1.45 to 4.35μ wide, the size varying with that of the cell body. The nerve cells n_{23-24} in the dorsal sector are anterior to the commissure of the corpus, while n_{29} is posterior to the commissure. Likewise the 2 most posterior ventral cells of the postcorpus (n_{30-31}) are posterior to the commissure.

The nerve cells of the bulb are in general similar to those of the postcorpus. Of these n_{33-37} are apparently bipolar, entering into the bulbar commissure, while $n_{36 \text{ and } 37}$ appear to be tripolar commissural cells.

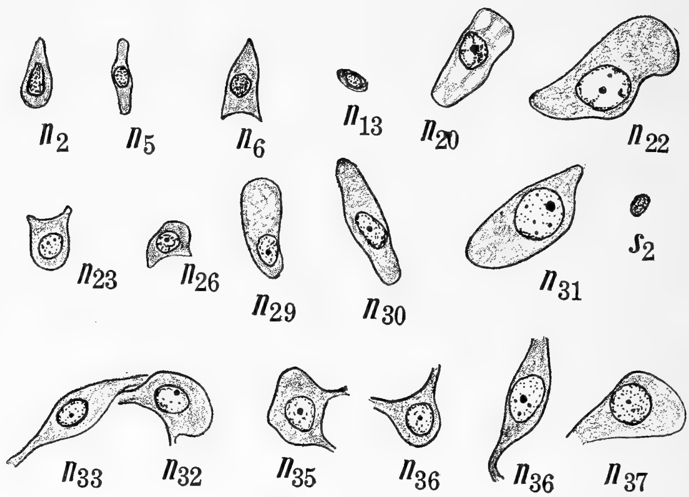

Fig. 3.—Nerve cells of esophagus. Labelled as in fig. 1.

The asymmetric dorsal nucleus (x_1) of the precorpus is 2μ long by 1.65μ wide, and stains somewhat similarly to the nerve cell nuclei of the postcorpus. The nuclei $s_{1 \text{ and } 2}$ are about 1.89μ long by 1.2μ wide, and very strongly basophilic (Fig. 3); these may possibly be nerve cells. The asymmetric nucleus (x_2) in the bulb is 3.3μ long by 1.65μ wide, and smaller than the marginal nuclei, but stains in a similar manner.

Esophageal glands. Nothing can be added at the present time to the description previously given by Chitwood (1931). There is no proof that functional subventral glands are present.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1071ST MEETING

The 1071st meeting was held in the Cosmos Club Auditorium, May 26, 1934, President DRYDEN presiding.

Program: L. R. HAFSTAD: *Atomic disintegration by high energy particles.*—Our first knowledge of the atomic nucleus was obtained in the discovery of the process of radioactivity by Becquerel in 1896. In 1919 a new branch of unlimited possibilities was started by Rutherford when he produced atomic transmutation for the first time by bombarding nitrogen with alpha-particles. Still another branch was started by Bothe and Becker in 1930, when they discovered that beryllium under alpha-particle bombardment emitted uncharged radiation of extremely great penetrating power. This observation stimulated experiments which led directly to proof of the existence of the neutron in 1932 and very recently, to the discovery of artificially-produced radioactivity. Quite independently, from cosmic-ray studies, Anderson in 1932 discovered the positive electron. As a result of these discoveries we are forced to admit the existence of nuclear processes and reactions much more complex than those originally imagined, which were based on only the proton and the electron as the elementary particles. At the present time a fairly satisfactory theory of the nucleus is being built up but is greatly handicapped by inconsistencies in experimental data. Even the fundamental question as to the mass of the neutron, for instance, cannot be considered as answered as yet for the experiments of Chadwick lead conclusively to the value 1.0067 while those of Curie and Joliot give just as conclusively the value 1.010. The latter experiments also give support for the hypothetical "neutrino." Experimental data are being rapidly accumulated at the present time which will permit such questions to be settled in the near future. Apparatus for the artificial acceleration of particles is proving especially effective since projectiles of mass 1 and mass 2 may be used in addition to alpha-particles for bombarding various elements. This removes one of the great restrictions of the work with radioactive sources in which only alpha-particles can be used. (*Author's abstract.*)

Discussed by Messrs. MOHLER, SEEGER, H. L. CURTIS, DRYDEN, R. E. GIBSON, TUCKERMAN, MEGGERS, and BRICKWEDDE.

Informal Communication: H. L. CURTIS.—There has recently been constructed at the National Bureau of Standards, a precision coil for a current balance in which the winding consists of two strips of aluminum wound simultaneously on an aluminum frame, and insulated from each other and from the frame by aluminum oxide. The strips are 6 mm wide by 0.07 mm thick, and the aluminum oxide coating, which was deposited on the strips electrolytically, is a few microns in thickness. An arrangement was made for wiping each strip with chamois just before it was wound on to the coil, thus preventing short circuits between the turns. With 45 turns in each winding, the insulation resistance between the windings, when the coil is dry, is several megohms. (*Author's abstract.*)

Discussed by Messrs. MOHLER, GISH, and TUCKERMAN.

1072ND MEETING

The 1072nd meeting was held in the Cosmos Club Auditorium, October 13, 1934, President DRYDEN presiding.

Program: W. E. DEMING: *Curve fitting and tests for empirical formulas.*—A review was given of the sampling distributions of the mean $\bar{x}$ and the standard deviation (S. D.) s in samples of n drawn from a normal parent population of mean μ and S. D. σ. When χ^2 is defined as ns^2/σ^2, the sampling distribution of χ^2 can be found immediately from the distribution of s. The single set of n observations constitutes the simplest possible problem in curve fitting; the line $x=a$ is to be fitted to the n observations to make s, and hence χ^2, a minimum. No matter how complicated the formula, the sampling distribution of χ^2 (defined as the sum of the weighted squares of the residuals, each residual being measured in units of σ, the r.m.s. error of observations of unit weight) is always a member of a certain one-parameter family of curves, the single parameter being k, the *number of degrees of freedom*, as it has been called by Fisher. k is the number of points fitted diminished by the number of independent adjustable constants in the empirical formula. From the distribution of χ^2 it is found that the average value of χ^2 is k, the number of degrees of freedom in the problem.

An unusually high value of χ^2 may arise from (a) pure chance; (b) the wrong empirical formula; (c) lack of control, or the presence of constant errors; (d) too low an assumed value of σ, the S. D. of observations of unit weight. To decide just which cause or causes may be operating in a given problem to give an unusually high value of χ^2 is a matter that requires caution and skill in interpretation, but it is important to note that a statistical analysis of the situation often leads to the detection of causes (b) and (c). In the case of a pair of means, the Chi-test is the same criterion as the test derived from the normal distribution of the difference of two means. In any problem the tables of $P(\chi^2)$ tell how unusual a given value of χ^2 is for different values of k.

When there is no opportunity of getting beforehand a reliable estimate of σ, another method of attack is by the *analysis of variance*, as it is called by Fisher. This consists of comparing the ratio ω of two estimates of σ. If σ' and σ'' denote the two estimates of σ that are obtained respectively by external and internal consistency (Birge, Phys. Rev. **40:** 207 1932), the ratio $\omega=\sigma'/\sigma''$ may be unusually high from the same four causes as outlined in the preceding paragraph, and the interpretation is exactly similar. Tables are provided by Fisher's *Statistical methods for research workers* and by Pearson's *Tables of the incomplete beta function.* In the case of a pair of means, this method reduces to the t-test devised by Student and Fisher.

Discussed by Messrs. WERTHEIMER, MCNISH, TUCKERMAN, NAIMAN, WULF, SILSBEE, and GOLDBERG.

Informal Communication: L. B. TUCKERMAN.—Mr. TUCKERMAN read a translation of a part of a communication entitled *Stilarten mathematischen Schaffens* by L. Bieberbach in the July 1934 number of the *Sitzungs Berichte der Preussischen Akademie der Wissenschaft* and a quotation from Hardy in *Nature*, No. 3381, August 18, 1934, commenting on this communication of Bieberbach.

F. G. Brickwedde, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

U. S. Department of Agriculture.—More than 100 guests attended the dedication services on October 20, of the new Zoological Laboratory building which has just been completed at the Beltsville Research Center, Beltsville, Md. Dr. Maurice C. Hall, chief of the Zoological Division of the Bureau of Animal Industry, presided. Among the speakers were: Dr. Cooper Curtice, who was the first member of the division and is now retired; Dr. Charles Wardell Stiles, who served as chief of the division; Dr. Albert Hassall, who until his recent retirement was assistant chief; Dr. Henry B. Ward, permanent secretary of the American Association for the Advancement of Sciences; Dr. W. E. Cotton, superintendent of the Bureau of Animal Industry Experiment Station at Bethesda, Md.; Dr. Lawrence A. Avery, superintendent of the new laboratory; and Earl C. Butterfield, newly appointed superintendent of the Beltsville Research center.

Frederick D. Richey has succeeded Knowles A. Ryerson as chief of the Bureau of Plant Industry, United States Department of Agriculture, effective October 23, 1934. Mr. Ryerson has resumed his earlier work with tropical fruits and will head a section of subtropical horticulture in the Bureau. Mr. Richey has been in the Bureau for more than twenty-three years, having headed the corn-breeding project in the Division of Cereal Crops and Diseases until January 1 of this year, when he was appointed Associate Chief of the Bureau. Dr. M. A. McCall, head of the Division of Cereal Crops and Diseases, and Dr. E. C. Auchter, head of the Division of Fruit and Vegetable Crops and Diseases, have been designated as assistant chiefs of the Bureau, but will continue also to direct the work of their respective divisions. H. E. Allanson, in charge of administrative operations, will continue in the same capacity with the title of business manager.

At the autumn meeting of the American Ornithological Union, held in Chicago, October 22 to 26 inclusive, the Bureau of Biological Survey was represented by the following: W. C. Henderson, W. B. Bell, W. L. McAtee, F. C. Lincoln, Clarence Cottam, H. C. Oberholser, E. A. Preble, E. A. Goldman, A. H. Howell, C. H. M. Barrett, Miss Phoebe Knappen, and J. Paul Miller.

The following papers were presented by Biological Survey representatives: W. B. Bell, *Some sidelights on the waterfowl breeding grounds;* Clarence Cottam, *The waterfowl situation;* F. C. Lincoln, *The four major waterfowl flyways;* E. A. Preble, *Waterfowl breeding grounds of northern Canada;* Miss Phoebe Knappen, *A neglected food resource.*

National Bureau of Standards.—On the evening of October 27, Dr. Lyman J. Briggs, director of the National Bureau of Standards addressed the Washington Philosophical Society at the Cosmos Club on the stratosphere flight of the balloon *Explorer.* He was followed by Dr. L. B. Tuckerman of the engineering mechanics section who spoke on the technical difficulties in stratosphere ballooning.

Dr. H. C. Dickinson recently completed road tests which indicate that on a highway where the speed limit is 45 miles an hour, and cars traveling 50 miles an hour are tolerated, a distance of 900 feet is needed for safe clearance. Time of passing is found to be nearly constant at six seconds on a level road and does not depend on the speed.

Dr. Paul R. Heyl, chief of the sound section, was severely injured in an automobile accident on October 20, suffering the loss of his right arm.

Dr. H. C. Dickinson, chief of the heat and power division, spoke before the American Road Builders' Association at the National Press Club on October 30.

V. B. Phelan, of the specifications division, attended a preview of the housing exhibition sponsored by the New York City Housing Authority at the Museum of Modern Art in New York City, as well as conferences on slum clearance and low-cost housing at Columbia University, on October 15 and 16. The Bureau prepared and installed an exhibit illustrating its activities in connection with materials, equipment, and services used in dwelling house construction. This exhibition opened on October 15 and continued through November 7.

Dr. F. S. Brackett of the Bureau of Agricultural Economics will devote part of his time to studies of sources of ultraviolet radiation as a special guest worker in the pyrometry section of the National Bureau of Standards.

C. J. Humphreys, formerly a member of the Bureau's spectroscopy section, has joined the physics department of the Massachusetts Institute of Technology.

U. S. National Park Service.—A special session of the National Park Educational Advisory Board was held in Washington, November 9 and 10. This session was called primarily to enable the members of the board to discuss national park wildlife problems with George M. Wright, chief of the Service's Wildlife Division, and Ben H. Thompson, also of that Division, who have been in Washington preparing the Recreation Section of the National Resources Board Report. The winter feeding grounds of the elk in Yellowstone National Park and the Trumpeter swan in Yellowstone were given special consideration at the meeting.

Invitations have been issued by Director Cammerer to national park superintendents, monument custodians, and field officials to attend a Superintendent's Conference in Washington, D. C., November 19, 20, and 21. It will be the purpose of the conference to consider important matters relating to the areas under the Service's jurisdiction and to discuss new policies that should be put into effect, or to be considered for adoption, as a result of changed conditions occasioned by the development of emergency programs and the increased use of park and monument areas by the public.

National Zoological Park.—The first barless pit to be installed at the National Zoological Park is now in use; at present it houses a number of flightless cormorants and swans. New acquisitions include a male muntjac, the first in Washington since 1910, mates for the kiang and the Indian blackbuck, a pair of barking garcias and three terra-terras.

The Roerich pact.—President Roosevelt has appointed Secretary of Agriculture Henry A. Wallace as United States plenipotentiary to sign the Roerich Pact. A treaty for American republics to sign has been drawn based on Nicholas Roerich's proposals. It provides that the nations regard as inviolable all artistic and scientific institutions and historic monuments. In event of fighting between American countries, the armies would respect sites marked with a banner, to be known as the Banner of Peace. No bombs would be dropped on cathedrals, museums, schools, universities, libraries,

or other cultural sites. These would be neutral territory, respected by all nations signing the treaty. The governments that have so far given notification of signing are Panama, Honduras, Uruguay, Ecuador, Guatemala, and the United States. The plan for protection of the world's scientific and artistic treasures against the destructiveness of war was presented by Roerich as far back as 1904. Had it been acted upon then in Europe, the Banner of Peace might have saved museums and other irreplaceable buildings and their contents, that were needlessly destroyed during the World War.

Optical Society meeting.—The Optical Society of America held its nineteenth annual meeting at the National Bureau of Standards, October 18 to 20. Among the outstanding contributions were papers by Dr. J. W. BEAMS of the University of Virginia, who reported that the human eye "sums up" or integrates into an apparent continuum the energy of a series of exceedingly short light flashes; by Dr. HAROLD MESTRES of Yale University, who described a densitometer method for studying the increase of bacteria in fluid cultures; and by Dr. ROGER S. ESTEY of the Electrical Testing Laboratories, New York City, on the use of heat-absorbing glass in air-conditioning installations where solar radiation is a considerable factor.

Child development meeting.—A meeting of the Society for Research in Child Development was held at the headquarters building of the National Academy of Sciences and the National Research Council, November 3 to 5. Among the speakers was Dr. JULIUS H. HESS of Chicago, who related progress in reducing the deathrate among prematurely born infants. Deathrate in such cases, born in hospitals, was reduced from 42 per cent in the period 1922–26, to 22.5 per cent in 1930–33. Dr. RUSSELL W. BUNTING of the University of Michigan reported a strong positive correlation between low-sugar diet and low incidence of dental caries in children. Dr. PAUL HANLY FURFEY of the Catholic University of America challenged the validity of much of the statistical analysis of child mentality measurement methods at present in vogue.

Memorial meeting at Ames.—At a meeting held at Iowa State College, Ames, on November 16 and 17, in commemoration of sixty years of modern plant study, inaugurated by the late Prof. CHARLES EDWIN BESSEY, Secretary of Agriculture HENRY A. WALLACE delivered an address on Sixty Years of Corn Breeding. The Soil Erosion Service of the U. S. Department of the Interior was represented at the meeting by R. E. UHLAND and Dr. W. C. LOWDERMILK, and the Bureau of Plant Industry, U.S. Department of Agriculture by A. F. DODGE.

Department of Terrestrial Magnetism.—Dr. J. BARTELS, research associate of the Carnegie Institution of Washington and professor of geophysics at the University of Berlin, and at the Forstliche Hochschule in Eberswalde, Germany, who has been engaged in research work at the Department of Terrestrial Magnetism, Carnegie Institution of Washington, since early in August, spoke at the staff meeting of the Department, October 17, on *Random fluctuations, persistence and quasi-persistence in geophysical and cosmical phenomena.* He sailed from New York en route to Germany on October 19.

F. T. DAVIES, of the Department of Terrestrial Magnetism, who was granted a furlough in order that he might take charge of the Canadian Polar-Year station at Chesterfield Inlet and assist in discussion of the results at the Meteorological Service in Toronto, returned to duty at the Department in Washington October 15.

NEWS BRIEFS

The annual meeting of the Official Agricultural Chemists was held in Washington, October 19 to 21.

A Committee on Hydrogen Isotopes has been organized under the auspices of the National Research Council, with Prof. H. C. UREY of Columbia University as its chairman. Drs. F. G. BRICKWEDDE and M. A. TUVE of the National Bureau of Standards are members of this committee.

Reorganization of Patent Office practice is advocated by D. H. KILLEFER of New York City, in a communication to the American Chemical Society. Mr. KILLEFER calls for less secrecy surrounding applications for patents, and for better salaries and more privileges for searchers, with the aim of building up a better trained and more permanent staff.

A shoal water fathometer has been perfected in the laboratories of the U. S. Coast and Geodetic Survey. It operates on the echo principle, already in use in the deep water fathometer, but improvements in accuracy permit measurements within a one-inch margin of error, and enable observers to read soundings, if desired, for every foot of bottom traversed at a cruising speed of ten knots.

The airship *Los Angeles* has been reconditioned as for cruising, but is to be kept on the ground and used only for mooring tests.

The U. S. Naval Observatory has inaugurated a new time-broadcasting schedule, putting the time signals on the air from the Station NAA, Arlington, twenty times every day. The signals are sent out every hour on the hour, except at 9 and 11 A.M. and 9 and 11 P.M., E.S.T., on a long wavelength of 113 kilocycles. The code broadcasts hitherto in use are also being continued.

The U. S. Weather Bureau reports only two tropical disturbances of hurricane force in West Indian waters during the past autumn, as compared with an all-time record number of 21 during the corresponding season of 1933.

New measurements and calculations by Dr. E. O. HULBURT of the U. S. Naval Research Laboratory indicate that the atmospheric temperature above the earth may be as high as 300 degrees Kelvin, or 80.6° Fahrenheit.

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An * denotes the abstract of a paper before the Academy or an affiliated society.

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